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PATENT
Attorney Docket No.: COOL-00901

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Group Art Unit: 3744
Mark Munch et al.	Examiner: Jiang, Chen Wen
Serial No.: 10/643,641	**TRANSMITTAL LETTER**
Filed: August 18, 2003	162 North Wolfe Road Sunnyvale, California 94086 (408) 530-9700
For: **REMEDIES TO PREVENT CRACKING IN A LIQUID SYSTEM**	Customer Number 28960

Mail Stop
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Enclosed please find a Appeal Brief including a check in the amount of $500.00 for filing with the U.S. Patent and Trademark Office.

The Commissioner is authorized to charge any additional fee or credit any overpayment to our Deposit Account No. 08-1275. **An originally executed duplicate of this transmittal is enclosed for this purpose.**

Respectfully submitted,
HAVERSTOCK & OWENS LLP

Dated: April 28, 2006

By: Thomas B. Haverstock
Thomas B. Haverstock
Reg. No.: 32,571

Attorneys for Applicants

CERTIFICATE OF MAILING (37 CFR§ 1.8(a))

I hereby certify that this paper (along with any referred to as being attached or enclosed) is being deposited with the U.S. Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to the: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450

HAVERSTOCK & OWENS LLP.

Date: 4-28-06 By:

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In re Application of:	Group Art Unit: 3744
Mark Munch et al.	Examiner: Jiang, Chen Wen
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Filed: August 18, 2003	**APPEAL BRIEF**
For: **REMEDIES TO PREVENT CRACKING IN A LIQUID SYSTEM**	160 North Wolfe Road Sunnyvale, California 94086 (408) 530-9700
	Customer No.: 28960

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Sir:

In furtherance of the Applicants' Notice of Appeal filed on March 13, 2006, this Appeal Brief is submitted herewith in triplicate. This Appeal Brief is submitted in support of the Applicants' Notice of Appeal filed on March 13, 2006, and further pursuant to the final rejection mailed on December 12, 2005. Claims 1-13, 25-35, 47-57, 70, and 133-135 have been rejected. The Applicants submit this Appeal Brief to the Board of Patent Appeals and Interferences in compliance with the requirements of 37 C.F.R. § 1.192. The Applicants contend that the rejection of Claims 1-13, 25-35, 47-57, 70, and 133-135 in this proceeding is in error and is overcome by this appeal.

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I. REAL PARTY IN INTEREST

As the assignee of the entire right, title, and interest in the above-captioned patent application, the real party in interest in this appeal is:

Cooligy, Inc.
800 Maude Ave
Mountain View, CA 94043

Recently moved from:

2370 Charleston
Mountain View, CA 94043

This assignment results from the assignment documents recorded on November 24, 2003, on reel number 014720 and frame number 0800.

II. RELATED APPEALS AND INTERFERENCES

The Applicants are not aware of any other appeals or interferences related to the present application.

III. STATUS OF THE CLAIMS

The pending U.S. Patent Application Serial Number 10/643,641 (the '641 patent application) was filed on August 18, 2003, and claims priority from U.S. Provisional Patent Application 60/444,269, filed on January 31, 2003.

A first Office Action was mailed on May 6, 2004, entering a restriction requirement. In the Amendment and Response to Restriction Requirement, filed on June 7, 2004, the Applicants withdrew claims 36-46, 58-69, and 71-132 as relating to unelected species.

In a second Office Action mailed July 19, 2004, claims 1-13, 25-35, 47-57, and 70 were rejected. An Amendment and Response was filed on October 12, 2004 and was deemed non-compliant. A Notice of Non-Compliant Amendment sent on November 2, 2005. A Response to Notice of Non-Compliant Amendment under 37 C.F.R. §1.121 was filed on December 6, 2004, the response addressed the rejection of claims 1-13, 25-35, 47-57, and 70.

An Office Action was mailed on February 1, 2005, finalizing the rejection of claims 1-13, 25-35, 47-57, and 70 under 35 U.S.C. § 102 or 35 U.S.C. § 103. A Response was filed on April 4, 2005, addressing the final rejection.

In an Office Action mailed on April 28, 2005, the Examiner withdrew the finality of the rejections made in the Office Action of February 1, 2005, but again rejected Claims 1-13, 25-35, 47-57, and 70 under 35 U.S.C. § 102 or 35 U.S.C. § 103, this time citing new references. A Response was timely filed on August 29, 2005 along with a request for extension of time and appropriate fee. The response added new claims 133 and 134, and amended claims 1, 25, 47, and 70.

A final Office Action was mailed on September 16, 2005. In the Office Action, the amendment was entered but the Examiner erroneously withdrew claims 1-13, 25-35, 47-57, and 70 as being drawn to a non-elected invention, in the alternative, the Examiner rejected the amended and new claims over the references introduced in the previous office action. An Amendment and Response was filed November 18, 2005. The response filed November 18, 2005 pointed out that the Examiner's withdrawal and rejection of the amended and new claims was tantamount to a refusal to enter the amendment, and was improper, and therefore included the same amendments to claims 25, 47, and 70, the same new claims 133 and 134, a different amendment to claim 1 and a new claim 135.

On December 12, 2005, a second final Office Action was mailed; the Office Action entered the amendment (including new claims 133-135), rejected Claims 1-13 and 135 under the first paragraph of 35 U.S.C. §112, and rejected Claims 25-35, 47-57, 70, 133, and 134 over the references introduced with the Office Action of April 28, 2005. The state of the claims is not at issue in this appeal; the claims included in the Appendix are consistent with the entered amendments made during the examination of the pending application. The rejection of Claims 1-13, 25-35, 47-57, 70, and 133-135 is being appealed.

IV. STATUS OF THE AMENDMENTS

No amendments have been filed after the final Office Action mailed on December 12, 2005. The present condition of the claims is as listed in the Response filed on November 18, 2005.

V. SUMMARY OF THE CLAIMED SUBJECT MATTER

The instant invention is separately argued in the independent claims 1, 25, 47, 70, 133, 134, and 135. Furthermore, the dependent claims 27 and 49 are argued separately, but only as a matter of form.

Claim 1 describes an apparatus for preventing cracking of a liquid system. The apparatus includes at least one heat exchanger [Original Specification, page 8, lines 21-31, FIGS. 1 and 10]; at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages [Original Specification, page 13, lines 23-24, FIG. 7]; at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages [Original Specification, page 13, lines 24-25, FIG. 7]; and one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10]; wherein, the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects [Original Specification, page 15, lines 10-12, FIG. 10; page 10, line 30 to page 11, line 26, FIGS. 4 and 5; FIG. 7].

Claim 25 describes an apparatus for preventing cracking of a liquid system. The apparatus comprises an enclosure [Original Specification in general; FIGS. 7 and 10]; and one or more compressible objects immersed in the enclosure [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10]. Further, the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards the one or more compressible objects [Original Specification, page 15, lines 10-12, FIG. 10; page 10, line 30 to page 11, line 26, FIGS. 4 and 5; FIG. 7].

Claim 47 describes a method of preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers [Original Specification, Page 2, lines 15-18; FIGS. 1, 10]. The method comprises the steps of providing an enclosure [Original Specification in general; FIGS. 7 and 10]; immersing one or more compressible objects in the enclosure [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10]; configuring the enclosure to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure; and immersing one or more compressible objects in the enclosure at the other locations [Original

Specification, page 15, lines 10-12, FIG. 10; page 10, line 30 to page 11, line 26, FIGS. 4 and 5; FIG. 7].

Claim 70 describes an apparatus for preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers [Original Specification, Page 2, lines 15-18; FIGS. 1, 10]. The apparatus comprises an enclosure [Original Specification in general; FIGS. 7 and 10], wherein the enclosure being capable of contracting and expanding between a minimum volume condition and a maximum volume condition with fluid expansion during freezing [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10], and further wherein the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure [Original Specification, page 15, lines 10-12, FIG. 10; page 10, line 30 to page 11, line 26, FIGS. 4 and 5; FIG. 7].

Claim 133 describes a method of preventing cracking of a liquid system that includes one or more pumps and one or more heat exchangers [Original Specification, Page 2, lines 15-18; FIGS. 1, 10]. The method comprises several steps, including the following: providing an enclosure [Original Specification in general; FIGS. 7 and 10]; and immersing one or more compressible objects in the enclosure [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10], wherein the one or more compressible objects are not covered by a separate membrane [Original Specification, page 4, lines 16-17].

Claim 134 describes an apparatus for preventing cracking of a liquid system. The apparatus comprises at least one heat exchanger [Original Specification, Page 2, lines 15-18; FIGS. 1, 10]; at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages [Original Specification, page 13, lines 23-24, FIG. 7]; at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages [Original Specification, page 13, lines 24-25, FIG. 7]; and one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10], wherein the one or more compressible objects are not covered by a separate membrane [Original Specification, page 4, lines 16-17].

Claim 135 An apparatus for preventing cracking of a liquid system. The apparatus comprises: at least one heat exchanger including a plurality of microchannels [Original

Specification, Page 2, lines 15-18; page 13, line 24; FIGS. 1, 7A, 10]; at least one inlet port extending through a first opening for conveying a fluid to the plurality of microchannels [Original Specification, page 13, lines 23-24, FIG. 7]; at least one outlet port extending through a second opening for discharging the fluid from the plurality of microchannels [Original Specification, page 13, lines 24-25, FIG. 7]; and one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port [Original Specification, page 13, lines 25-28, FIG. 7; page 14, line 31 to page 15, line 1, FIG. 10]; wherein, the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port [Original Specification, page 15, lines 10-12, FIG. 10; page 10, line 30 to page 11, line 26, FIGS. 4 and 5; FIG. 7].

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection for review by the Board of Patent Appeals and Interferences are as follows:

1. Claims 1-13, and 135 stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement;
2. Claims 25, 26, 28-35, 47, 48, 50-57, 70, 133 and 134 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent Number 6,119,729 to Oberholzer *et al.* ("Oberholzer");
3. Claims 27 and 49 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Oberholzer; and
4. Claims 27 and 49 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Oberholzer in view of Japanese Patent No. JP 10099592 to Mihara ("Mihara").

VII. ARGUMENT

The claims pending on appeal in this proceeding do not stand or fall together.

Regarding the rejection of Claims 1-13, and 135 under 35 U.S.C. §112, first paragraph: Claims 1-13 and 135 do not stand or fall together because they contain different limitations.

Appellant sets forth below why the claims are believed to be separately patentable, and therefore should not stand or fall according to the grouping of the claims presented in this rejection. Relevant to this rejection: Claims 1-13 can be grouped together, and Claim 135 should stand on its own.

Regarding the rejection of Claims 25, 26, 28-35, 47, 48, 50-57, 70, 133 and 134 under §102(b) as anticipated by Oberholzer: Claims 25, 26, 28-35, 47, 48, 50-57, 70, 133 and 134 do not stand or fall together because they contain different limitations. Appellant sets forth below why the claims are believed to be separately patentable, and therefore should not stand or fall according to the grouping of the claims presented in this rejection. Relevant to this rejection: Claims 25, 26, and 28-35 can be grouped together, Claims 47, 48, and 50-57 can be grouped together, and each of Claims 70, 133, and 135 should stand on its own.

Regarding the rejection of Claims 27 and 49 under §103(a) as unpatentable over Oberholzer either alone or in view of Mihara: Claims 27 and 49 do not stand or fall together because they contain different limitations. Appellant sets forth below why the claims are believed to be separately patentable, and therefore should not stand or fall according to the grouping of the claims presented in this rejection. Relevant to this rejection: Claims 27 should stand or fall with claim 25, and claim 49 should stand or fall with claim 47.

A. THE REJECTION UNDER §112, FIRST PARAGRAPH, IS IN ERROR.

Claims 1-13 and 135 were rejected under §112, first paragraph, as failing to comply with the written description requirement. Specifically, the Examiner states that the claims contain subject matter that was not described in the specification in such a way as to reasonably convey to one skilled in the art that the inventors, at the time the application was filed, had possesion of the claimed invention.

In the Response filed on August 29, 2005, Appellant attempted to amend Claims 1, 25, 47, and 70, and added new claims 133-134. In a subsequent final Office Action, mailed September 16, 2005, the amendements were not entered and it was stated "newly submitted claims 1-13, 25-35, 47-57, and 70 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons: The amended claims do not read on Applicant's election of Species X (Fig. 10). The amended limitations have not been disclosed in Fig. 10." The Examiner then stated that all amended claims were withdrawn from consideration as being directed to a non-elected invention. Further, the Examiner stated, "The previous Office

Action still valid (*sic*) since Oberholzer et al. disclose the system same (*sic*) as Applicant elected Fig. 10." The Office Action did not address new claims 133-134.

In the Response filed on November 18, 2005, Appellant pointed out that an applicant's right to limit claims by amedment is well settled, and demonstrated that the proper procedure for an Exmainer reasserting that the claims are drawn to non-elected species is to phrase it as a §112, second paragraph rejection. Hence, Appellant filed an amendment identical to that filed in the previous response as regards claims 25, 47, 70, 133, and 134, and including new claim 135 and a different amendment to claim 1, and requested that the amendment be entered.

The Final Office Action, mailed December 12, 2005, was silent as to whether the claims are drawn to the elected species. The amendment was entered, but Claims 1-13 and 135 were rejected under §112, first paragraph as failing to comply with the written description requirement. In the Office Action, it was stated:

> "The fluid in the inlet and outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects" and "the heat exchanger is configured so that fluid within the pluality of microchannels freezes before fluid within the outlet port and the inlet port" have not been disclosed in the specification.

The Examiner's erroneous withdrawal of the claims in the previous Office Action was not mentioned within the Final Office Action. Appellant submits that their Response filed November 18, 2005 has removed those rejections that are not referred to in the Final Office Action.

Under Federal Circuit law, a patent application must satisfy two separate and distinct requirements under §112, first paragraph: it must describe both the invention and how to make and use it. <u>See</u> *Vas-Cath, Inc. v. Mahurkar*, 935 F.2d 1555, 1560 (Fed. Cir. 1991). The Final Office Action did not raise the issue of enablement under §112, first paragraph; accordingly, only compliance with the written description requirement will be discussed.

1. The burden to prove lack of compliance with the written description requirement falls on the Examiner, <u>who failed to present a *prima facie* case</u>

The Examiner has the initial burden of presenting by a preponderance of evidence why a person skilled in the art would not recognize in an applicant's disclosure a description of the invention defined by the claims, including new or amended claims. <u>See</u> *In re Wertheim*, 541 F.2d 257, 263 (CCPA 1976).[1]

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[1]The Patent and Trademark Office has this burden, but recommends that an applicant filing an amendment show support in the original disclosure for the new or amended claims;

In the Response filed November 18, 2005, which introduced an amendment to claim 1 and added new claim 135, Appellant specifically pointed out where in the original disclosure the newly claimed subject matter finds support, stating:

> The election of species X [FIG. 10]...does not exclude limitations disclosed as associated with systems such as the one of FIG. 10 elsewhere in the specification[;]...note that in lines 10-12 of page 15, the specification discusses the inclusion of various techniques for freeze prevention discussed elsewhere[,] within the system of FIG. 10.

The Final Office Action provides no convincing evidence to support the rejection for lack of adequate written description. The plain language of the rejection indicates that Appellant's claims are being held to a standard far higher than that required by law.

The relevant inquiry according to Federal Circuit law goes to how one skilled in the art would interpret the specification. See, *Vas-Cath*, 935 F.2d at 1563. Literal disclosure is not required. *Martin v. Johnson*, 454 F.2d 746, 751 (CCPA 1972) (stating "the description need not be in *ipsis verbis* to be sufficient").

In the paragraph rejecting claims 1-13 and 135 under §112, first paragraph, the Examiner simply quotes two newly added claim limitations and alleges that these limitations "have not been disclosed in the specification." Since the Examiner makes no mention of how a person skilled in the art would interpet the specification, Applicants submit that the Examiner is either requiring literal disclosure or substituting his judgement for that of one of ordinary skill in the relevant art. Neither action is acceptable.

Accordingly, because the Examiner presents no *prima facie* case for lack of compliance with the written description requirement, Appellant submits that the rejection under §112, first paragraph, is in error and should be removed.

2. The original specification contains a written description sufficient to reasonably convey to one skilled in the art that the inventors, at the time of the invention had possession of the invention of claims 1-13 and 135

Despite the examiner's failure to present a *prima facie* case detailing how claims 1-13 and 135 fail to comply with the written description requirement, and for the conveinence of the Appeal Board, Appellant sets forth in the following section how the claims 1-13 and 135 are in fact in compliance with the written description requirement of §112, first paragraph.

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however, in making this recommendation, the PTO cites no legal authority. See MPEP §2163(II)(A)(3)(b).

As the Court of the Federal Circuit recently noted: "The purpose of the written description requirement is to prevent an applicant from later asserting that he invented that which he did not; the applicant for a patent is therefore required 'to recount his invention in such detail that his future claims can be determined to be encompassed within his original creation.'" See *Amgen Inc. v. Hoechst Marion Roussel Inc.*, 314 F.3d 1313, 1330 (Fed. Cir. 2003) (citing *Vas-Cath*, 935 F.2d at 1561).

Compliance with the written description requirement is a question of fact that must be resolved on a case-by-case basis. See *Vas-Cath,* 935 F.2d at 1563. Furthermore, compliance requires sufficient information in the specification to show that the inventor possessed the invention at the time of that original disclosure. See *Id.* at 1561 ("Adequate description of the invention guards against the inventor's overreaching by insisting that he recount his invention in such detail that his future claims can be determined to be encompassed within his original creation."). The test of sufficiency requires only that the disclosure convey the invention with *reasonable clarity* and that assessment of said clarity be done from the viewpoint of *one of skill in the art.* See *Id.* at 1563-64 ("[T]he applicant must . . . convey with reasonable clarity to those skilled in the art that, as of the filing date sought, he or she was in possession *of the invention.*" (emphasis in original)); See Also *Union Oil Co. of Cal. v. Atl. Richfield Co.*, 208 F.3d 989, 997 (Fed. Cir. 2000) ("The written description requirement does not require the applicant 'to describe exactly the subject matter claimed, [instead] the description must clearly allow persons of ordinary skill in the art to recognize that [the inventor] invented what is claimed.'" (citation omitted)).

Now, to show possession of the claimed invention, the orignal disclosure can describe the claimed invention with all of its limitations using such descriptive means as words, structures, figures, diagrams, and formulas that fully set forth the claimed invention. See *Lockwood v. American Airlines, Inc.*, 107 F.3d 1565, 1572, (Fed. Cir. 1997). Of course, as emphasized above, the disclosure must be viewed from the perspective of one skilled in the art.

a) Within the orignal disclosure of the instant application, the invention of current claim 1 is described, either implicitly or explictitly, with all of its limitations.

Claim 1 recites an apparatus for preventing cracking of a liquid system, comprising at least one heat exchanger; at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages; at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that

the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port; *wherein, the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects.*

With the exception of the italicized portion, the claim is as originally submitted. There should be no doubt that the genus set forth by the original claim 1, of which the current claim 1 is a subgenus, is described within the original application. See *In re Koller*, 613 F.2d 819, (CCPA 1980) (original claims constitute their own description). However, there remains the issue of whether that description is sufficient by the standard of *Vas-Cath* mentioned above. Accordingly, and for completeness, Appellant will treat the support of each sub-paragraph within claim 1.

The preamble states that the claim is to "an apparatus for preventing cracking of a liquid system." From the first subparagraph, we find the apparatus includes "at least one heat exchanger." The orignal specification describes and depicts cooling systems that include a heat exchanger in FIGS. 1 and 10, and associated description at page 8, lines 21-31 and page 14, line 29 to page 15, line 12. Further, the original specification describes and depicts heat exchangers with reference to FIG. 7A at page 13, lines 21-28, and FIG. 7B at page 13, line 29 to page 14, line 8.

The second subparagraph recites "at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages." The claim read as a whole indicates that the inlet port is part of the heat exchanger. Further, the original FIG. 7A depicts a heat exchanger 130 with an inlet port 131 for conveying fluid to microchannels 138, as described in the original specification at page 13, lines 23-24.

The third subparagraph recites "at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages." With this structure too, the claim read as a whole indicates the outlet port is part of the heat exchanger. Further, the orignal FIG. 7A depicts a heat exchanger 130 with an outlet port 135 for discharging fluid from microchannels 138, as described in the original specification at page 13, lines 24-25.

The fourth subparagraph describes "one or more compressible objects coupled to the inlet and outlet ports" Original FIG. 7A depicts a heat exchanger 130 with compressible objects 132 coupled to its inlet port 131, and compressible objects 134 coupled to its outlet port 135. In addition, original FIG. 10 depicts a heat exchanger (unnumbered, but compare to the heat exchanger 20 of FIG. 1) included as part of a liquid cooling system in which compressible

elements partially fill all fluid segments of a cooling loop. [Original Specification, page 14, line 32 to page 15, line 1]

The fourth subparagraph further states that the compressible objects are coupled "in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port." According to the description associated with FIG. 7A, the compressible objects 132 and 134 are "preferably designed and arranged such that [they] can be partially displaced to accommodate expansion of ice without cracking itself or other rigid elements of the inlet and outlet ports." [Original Specification, page 13, lines 25-28] The specification teaches elsewhere that "freezing...inside confined spaces" and the associated "expansion" can increase pressure within a system containing the freezing fluid. [Original Specification, Background of the Invention] In this context, that the objects 132 and 134 "accommodate expansion of ice" clearly indicates that they accommodate the increased pressure caused by the expansion of the ice. One skilled in the relevant art knows that volume and pressure are inversely correlated. This notion, combined with the structure shown in FIG. 7A, indicates to one skilled in the art that the objects 132 and 134 reduce a volume of the inlet port and the outlet port, and by compressing under pressure, allow for the increase of a volume of the inlet and outlet port.

Above, Appellant has shown that the genus described by the first four subparagraphs of claim 1 (i.e. the original claim 1) is supported by the original disclosure. The fifth subparagraph contains the limitations, introduced by amendment, that are subject to rejection for lack of compliance with the written description requirement. The limitations relate to the specific configuration of the heat exchanger, and accordingly represent a sub-genus of the genus of the first four subparagraphs. The appropriate test according to *Vas-Cath* is whether the original disclosure contained sufficient description to reasonably convey to one skilled in the art that the inventors had invented this sub-genus. Here again, a fact specific inquiry is necessary.

Relevant precedents provide some guidance. For instance, a "laundry list" disclosure of every possible moiety does not always constitute a written description of every species in a genus. See *Fujikawa v. Wattanasin*, 93 F.3d 1559, 1571 (Fed. Cir. 1996). A classic analogy of the Federal Circuit compares a genus and its species to a forest and its trees; a description points out particular trees via "blazemarks". In *Fujikawa*, the "laundry list" contained insufficient "blazemarks" to point out which among the disclosed species are of special interest. See *Id.* at 1571, Citing *In re Ruschig*, 379 F.2d 990, 994-995 (CCPA 1967) However, this rule may only

apply in cases where the art provides no guidance to the skilled practitioner as to the desirability of certain species. See *Union Oil of Cal. v. Atlantic Richfield Co.*, 208 F.3d 989, 1000-1001 (Fed. Cir. 2000). In the current matter, the original specification discloses a set of sub-geni having particular desirability, of which the sub-genus of claim 1 is one. Furthermore, knowledge of the art would lead a skilled reader of the original specification to understand that the sub-genus of claim 1 had been invented by Appellant.

The fifth subparagraph states that "the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects." The original specification sets forth several species of heat exchanger which read on the limitation.

i) Each species of heat exchanger presented within the original specification discloses and describes several sub-species thereof

The original specification contains references to the desirability of using various embodiments in combination with one another. For example, on page 16, line 31, the specification reads: "In the above-described embodiments, the present invention is applied to a pump or a housing having an inlet chamber and an outlet chamber. Alternatively, the present invention may be applied to any enclosure in a liquid cooling system." This passage indicates that the various freeze-damage prevention methods disclosed as relating to pumps or housings could equally be applied to heat exchangers. Thus, the specification points to specific sub-species of each heat exchanger species discussed in the specification.

Consider the forest of the Federal Circuit's analogy. Recent cases have focused on the forest as genus with hundreds of trees as its species; instead, imagine a genus comprising the thousands possible paths through the forest. Imagine that some tens of trees are marked with blazes, but that three different types of blazes have been used. A naive hunter might view each type of blaze as corresponding to a path, and thus think that there are only three paths marked. However, imagine that the person marking the paths disclosed that paths including two or even three different types of blazes are possible. This is the scenario in the present appeal. The original specification indicated that embodiments described using a pump, for example, could also be applied to a heat exchanger, or other enclosure within a liquid system.

ii) Several subspecies associated with FIG. 7A read on claim 1.

As described above, FIG. 7A presents a heat exchanger 130 with inlet port 131 and outlet port 135 that are large relative to microchannels 138 that connect them. Multiple subspecies

pointed to by the original specification combine the heat exchanger 130 with the freeze damage prevention method of FIG. 4.

The description associated with FIG. 4 motivates combination with other embodiments containing compressible objects. First, it is noted that, "a critical factor is the use of any material or structure that assists a particular location become cold fastest [*sic*], and so that progression of freezing is continuous from that location to the air pockets 85 and 87 of Figure 4." [Original Specification, page 11, line 19] Examples of how to do this are given in the preceeding paragraph: "provid[ing] a thermal path from the location of initial freezing to its surroundings[,]...reducing the size and volume of the chamber or reducing package insulation in the chamber..."

Second, the specification teaches one skilled in the art that the air pockets 85 and 87 of FIG. 4 and the compressible objects 132 and 134 of FIG. 7A are equivalent, stating "in some cases, it may be difficult to control the positioning and location of the air pockets...[or]... to dispose an air pocket in each chamber of the system...;" within the same paragraph, the use of compressible objects is disclosed. [Original Specification, page 11, line 33] In addition, the specification teaches that "compressible objects can be made of ...air filled bubbles, [or] balloons..." [Original Specification, page 3, lines 2-3] Thus, the clear teaching of the original specification is that compressible objects are equivalent to air pockets, but preferable because they are more easily retained in a selected location.

In view of FIG. 4 and associated description, the description associated with FIG. 7A points one skilled in the art to sub-species which read on the claim 1. First, FIG. 7A and associated description teach that the microchannels 138 have significantly smaller size and volume than the inlet port 131 and the outlet port 130. This teaching, in conjunction with the teaching related to FIG. 4 that reducing size and volume of a chamber is a way to arrange a location of initial freezing in a chamber, points out to one skilled in the art that at least sub-species of the heat exchanger related to FIG. 7A is configured so that fluid within the microchannels freezes before fluid in the inlet and outlet ports, ergo "fluid in the inlet and outlet ports freezes later than the fluid elsewhere in the heat exchanger" as required by claim 1. Further, the teaching associated with FIG. 4 that freezing progress from the location of initial freezing to the air pockets would indicate to one skilled in the art that another desirable feature of the sub-species is "for freezing to advance towards the one or more compressible objects."

Second, surface 137 of FIG. 7A is a heat exchange surface. One skilled in the art knows that efficient heat exchange across surface 137 occurs if it has high thermal conductivity. This

fact, in combination with the teaching of FIG. 4 and associated description that a "thermal path between the location of initial freezing and its surroundings" can determine a location of initial freezing, indicates to one skilled in the art that freezing occur within the microchannels prior to other chambers in the system (which need not have heat conductive walls). Once the initial freezing of the microchannels is taught, the rest of claim 1 is taught as in the size and volume case above.

iii) Several sub-species associated with FIG. 10 read on claim 1

The description associated with FIG. 10 states that "relatively large reservoirs of fluid are likely to be in the chambers of the pump or the tubing in a heat exchanger." [Original Specification, page 15, lines 6-8] The description goes on to describe how elimination of these volumes is preferable, but admits "if large volumes of fluid are needed to guarantee sufficient fluid over extended use, the embodiments described above can reduce forces generated during freezing to manageable levels." [Original Specification, page 15, lines 10-12] Because each species of heat exchanger presented within the original specification discloses and describes several sub-species thereof as described above, the original specification teaches that the system of FIG. 10 include freeze protection embodiments such as those of FIG. 4, and those of FIG. 7A described above. The manner in which including such heat exchangers in the system of FIG. 10 would indicate to one skilled in the art that Appellant had invented a system that reads on claim 1 is similar to the process outlined above with reference to FIG. 7A.

Accordingly, the invention recited in claim 1 is pointed out within the original specification in a manner sufficient to reasonably convey to one skilled in the art that it had been invented by Appellant. As described above, the knowledge of one skilled in the art would lead that skilled reader to realize which among the sub-genii pointed to are desirable.

To extend our version of the forest analogy, imagine a skilled artisan as a hunter possessing a compass and attempting to travel in a known direction along one of the disclosed paths. This hunter could choose among the three types of blaze marks available at each step to ensure he moved in his chosen direction.

Since claims 2-13 all depend from claim 1 and do not include any disputed limitations, these claims are allowable as being dependant from an allowable base claim.

b) Within the orignal disclosure of the instant application, the invention of current claim 135 is described, either implicitly or explicitly, with all of its limitations.

Claim 135 recites an apparatus for preventing cracking of a liquid system, comprising at least one heat exchanger; at least one inlet port extending through a first opening for conveying a fluid to a plurality of *microchannels*; at least one outlet port extending through a second opening for discharging the fluid from the plurality of *microchannels*; and one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port; *wherein, the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port.*

With the exception of the italicized portions, the claim is identical to as originally submitted. There should be no doubt that the genus set forth by the original claim 1, of which the current claim 135 is a subgenus, is described within the original specification. Further, the issue of whether that description is sufficient by the standard of *Vas-Cath* has been treated above.

Claim 135 differs from original claim 1 in that its "channels and passages" are limited to "microchannels" and further that it includes a heat exchanger having a specific configuration. Accordingly, claim 135 represents a sub-genus of the genus of the original claim 1. There remains the issue of whether the sub-genus of claim 135 is described within the original specification. The appropriate test according to *Vas-Cath* is whether the original disclosure contained sufficient description to reasonably convey to one skilled in the art that the inventors had invented this sub-genus.

Here again, a fact specific inquiry is necessary. This inquiry contains two portions, one of which concerns whether a sub-genus of original claim 1 where the "plurality of channels and passages" are "microchannels" is described. The other portion concerns whether said sub-genus is further described to the effect that its "heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port."

Relevant precedents provide some guidance. For instance, a "laundry list" disclosure of every possible moiety does not always constitute a written description of every species in a genus. See *Fujikawa v. Wattanasin*, 93 F.3d 1559, 1571 (Fed. Cir. 1996). A classic analogy of the Federal Circuit compares a genus and its species to a forest and its trees; a description points out particular trees via "blazemarks". In *Fujikawa*, the "laundry list" contained insufficient "blazemarks" to point out which among the disclosed species are of special interest. See *Id.* at 1571, Citing *In re Ruschig*, 379 F.2d 990, 994-995 (CCPA 1967) However, this rule may only apply in cases where the art provides no guidance to the skilled practitioner as to the desirability

of certain species. See *Union Oil of Cal. v. Atlantic Richfield Co.*, 208 F.3d 989, 1000-1001 (Fed. Cir. 2000). In the current matter, the original specification discloses a set of sub-geni having particular desirability, of which the sub-genus of claim 135 is one. Furthermore, knowledge of the art would lead a skilled reader of the original specification to understand that the sub-genus of claim 135 had been invented by Appellant.

i) a sub-genus of original claim 1 where the plurality of channels and passages are microchannels is described within the original specification

In the preamble and first subparagraph, claim 135 recites an apparatus that includes "at least one heat exchanger." The orignal specification describes and depicts cooling systems that include a heat exchanger in FIGS. 1 and 10, and associated description at page 8, lines 21-31 and page 14, line 29 to page 15, line 12. Further, the original specification describes and depicts heat exchangers with reference to FIG. 7A at page 13, lines 21-28, and FIG. 7B at page 13, line 29 to page 14, line 8. The heat exchangers of FIGS. 7A and 7B are described as including microchannels.

The second subparagraph recites "at least one inlet port extending through a first opening for conveying a fluid to a plurality of microchannels." The claim read as a whole indicates that the inlet port is part of the heat exchanger. Further, the original FIG. 7A depicts a heat exchanger 130 with an inlet port 131 for conveying fluid to microchannels 138, as described in the original specification at page 13, lines 23-24.

The third subparagraph recites "at least one outlet port extending through a second opening for discharging the fluid from the plurality of microchannels." With this structure too, the claim read as a whole indicates the outlet port is part of the heat exchanger. Further, the orignal FIG. 7A depicts a heat exchanger 130 with an outlet port 135 for discharging fluid from microchannels 138, as described in the original specification at page 13, lines 24-25.

The fourth subparagraph describes "one or more compressible objects coupled to the inlet and outlet ports" Original FIG. 7A depicts a heat exchanger 130 with compressible objects 132 coupled to its inlet port 131, and compressible objects 134 coupled to its outlet port 135. In addition, original FIG. 10 depicts a heat exchanger (unnumbered, but compare to the heat exchanger 20 of FIG. 1) included as part of a liquid cooling system in which compressible elements partially fill all fluid segments of a cooling loop. [Original Specification, page 14, line 32 to page 15, line 1]

The fourth subparagraph further states that the compressible objects are coupled "in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port." According to the description associated with FIG. 7A, the compressible objects 132 and 134 are "preferably designed and arranged such that [they] can be partially displaced to accommodate expansion of ice without cracking itself or other rigid elements of the inlet and outlet ports." [Original Specification, page 13, lines 25-28] The specification teaches elsewhere that "freezing...inside confined spaces" and the associated "expansion" can increase pressure within a system containing the freezing fluid. [Original Specification, Background of the Invention] In this context, that the objects 132 and 134 "accommodate expansion of ice" clearly indicates that they accommodate the increased pressure caused by the expansion of the ice. One skilled in the relevant art knows that volume and pressure are inversely correlated. This notion, combined with the structure shown in FIG. 7A, indicates to one skilled in the art that the objects 132 and 134 reduce a volume of the inlet port and the outlet port, and by compressing under pressure, allow for the increase of a volume of the inlet and outlet port.

i) the sub-genus of original claim 1 where the plurality of channels and passages are microchannels is described to include a heat exchanger configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the <u>inlet port within the original specification</u>

The fifth subparagraph states that "the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port." The original specification sets forth several species of heat exchanger which read on the limitation.

(1) Each species of heat exchanger presented within the original <u>specification discloses and describes several sub-species thereof</u>

The original specification contains references to the desirability of using various embodiments in combination with one another. For example, on page 16, line 31, the specification reads: "In the above-described embodiments, the present invention is applied to a pump or a housing having an inlet chamber and an outlet chamber. Alternatively, the present invention may be applied to any enclosure in a liquid cooling system." This passage indicates that the various freeze-damage prevention methods disclosed as relating to pumps or housings could equally be applied to heat exchangers. Thus, the specification points to specific sub-species of each heat exchanger species discussed in the specification.

Consider the forest of the Federal Circuit's analogy. Recent cases have focused on the forest as genus with hundreds of trees as its species; instead, imagine a genus comprising the thousands possible paths through the forest. Imagine that some tens of trees are marked with blazes, but that three different types of blazes have been used. A naive hunter might view each type of blaze as corresponding to a path, and thus think that there are only three paths marked. However, imagine that the person marking the paths disclosed that paths including two or even three different types of blazes are possible. This is the scenario in the present appeal. The original specification indicated that embodiments described using a pump, for example, could also be applied to a heat exchanger, or other enclosure within a liquid system.

(2) Several subspecies associated with FIG. 7A read on claim 135

As described above, FIG. 7A presents a heat exchanger 130 with inlet port 131 and outlet port 135 that are large relative to microchannels 138 that connect them. Multiple subspecies pointed to by the original specification combine the heat exchanger 130 with the freeze damage prevention method of FIG. 4.

The description associated with FIG. 4 motivates combination with other embodiments containing compressible objects. First, it is noted that, "a critical factor is the use of any material or structure that assists a particular location become cold fastest [*sic*]" [Original Specification, page 11, line 19] Examples of how to do this are given in the preceeding paragraph: "provid[ing] a thermal path from the location of initial freezing to its surroundings[,]...reducing the size and volume of the chamber or reducing package insulation in the chamber..."

Second, the specification teaches one skilled in the art that the air pockets 85 and 87 of FIG. 4 and the compressible objects 132 and 134 of FIG. 7A are equivalent, stating "in some cases, it may be difficult to control the positioning and location of the air pockets...[or]... to dispose an air pocket in each chamber of the system...;" within the same paragraph, the use of compressible objects is disclosed. [Original Specification, page 11, line 33] In addition, the specification teaches that "compressible objects can be made of ...air filled bubbles, [or] balloons..." [Original Specification, page 3, lines 2-3] Thus, the clear teaching of the original specification is that compressible objects are equivalent to air pockets, but preferable because they are more easily retained in a selected location.

In view of FIG. 4 and associated description, the description associated with FIG. 7A points one skilled in the art to sub-species which read on the claim 1. First, FIG. 7A and associated description teach that the microchannels 138 have significantly smaller size and

volume than the inlet port 131 and the outlet port 130. This teaching, in conjunction with the teaching related to FIG. 4 that reducing size and volume of a chamber is a way to arrange a location of initial freezing in a chamber, points out to one skilled in the art that at least sub-species of the heat exchanger related to FIG. 7A is configured so that "fluid within the plurality of microchannels freezes before fluid in the inlet port and the outlet port" as required by claim 135.

Second, surface 137 of FIG. 7A is a heat exchange surface. One skilled in the art knows that efficient heat exchange across surface 137 occurs if it has a high thermal conductivity. This fact, in combination with the teaching of FIG. 4 and associated description that a "thermal path between the location of initial freezing and its surroundings" can determine a location of initial freezing, indicates to one skilled in the art that freezing occur within the microchannels prior to other chambers in the system (which need not have heat conductive walls).

(3) <u>Several sub-species associated with FIG. 10 read on claim 135</u>

The description associated with FIG. 10 states that "relatively large reservoirs of fluid are likely to be in the chambers of the pump or the tubing in a heat exchanger." [Original Specification, page 15, lines 6-8] The description goes on to describe how elimination of these volumes is preferable, but admits "if large volumes of fluid are needed to guarantee sufficient fluid over extended use, the embodiments described above can reduce forces generated during freezing to manageable levels." [Original Specification, page 15, lines 10-12] Because each species of heat exchanger presented within the original specification discloses and describes several sub-species thereof as described above, the original specification teaches that the system of FIG. 10 include freeze protection embodiments such as those of FIG. 4, and those of FIG. 7A described above. The manner in which including such heat exchangers in the system of FIG. 10 indicates to one skilled in the art that Appellant had invented a system that reads on claim 135 is similar to the process outlined above with reference to FIG. 7A.

Accordingly, the invention recited in claim 135 is pointed out within the original specification in a manner sufficient to reasonably convey to one skilled in the art that it had been invented by Appellant. As described above, the knowledge of one skilled in the art is helpful in realizing which specific sub-genii pointed to are most desirable.

To extend our version of the forest analogy, imagine a skilled artisan as a hunter possessing a compass and attempting to travel in a known direction along one of the disclosed

paths. This hunter could choose among the three types of blaze marks available at each step to ensure he moved in his chosen direction.

B. THE CLAIMS IN THE '641 APPLICATION ARE ALLOWABLE OVER THE CITED PRIOR ART.

1. Claims 25,26,28-35,47,48,50-57, and 70 are allowable over Oberholzer.

Within the Final Office Action, Claims 25,26,28-35,47,48,50-57,70,133, and 134 were rejected under § 102(b) as being anticipated by Oberholzer.

Furthermore, Claims 27 and 49 were rejected under § 103(a) as being unpatentable over Oberholzer, either alone or in view of Mihara. 6,186,722 to Shirai. Claim 27 depends from claim 25 and claim 49 depends from claim 47. As stated above, for purposes of this appeal, claim 27 stands or falls with claim 25, and claim 49 stands or falls with claim 47. Accordingly, the teachings of Mihara are irrelevant and are not discussed in this Appeal Brief.

a) Oberholzer discloses a longitudinally symmetrical, freeze protected conduit with a compressible insert disposed along its entire length

According to Oberholzer, a freeze-protected conduit 10 has a length, and comprises an elongated conduit 12 and an elongated compressible insert 20, which includes membrane 18 and compressible elastomeric material 14, disposed along its length. [Oberholzer, col. 4, lines 42-47 and FIG. 1] Further, according to Oberholzer, "preferably, the insert 20 is disposed along the axis of the conduit, particularly where conduit 12 is used in heat transfer applications." [Oberholzer, col. 4, line 66] Oberholzer contends that with the insert 20 centrally located, it will not interfere with heat transfer between the conduit wall and the aqueous liquid in the fluid passage 24.

For a conduit to be freeze protected according to Oberholzer, that conduit must contain an elastomeric insert. Though Oberholzer later discloses that some channels within a solar thermal collector system need not contain inserts, these channels are only those that are not exposed to cold temperature conditions: "where [fluid passages between a collector unit and supply line] are exposed to cold temperature conditions, the corresponding conduit is protected from freeze carnage by the present invention." [Oberholzer, col. 8, lines 46-54] Further, the conduit systems described in FIGS. 1 and 1a include inserts along their entire length. Thus, according to Oberholzer, only conduits containing inserts along their entire length are disclosed as freeze protected.

b) Oberholzer discloses a freeze protected conduit that is substantially radially symmetrical

The freeze protected conduit taught by Oberholzer in FIGS. 1 and 1a was cited in particular by the Final Office Action as anticipating the present invention. The freeze protected conduit 10 includes a cylindrical conduit 12 with a cylindrical insert 10 disposed along its central axis. These two structures form an annular fluid path 24. The cited portion of Oberholzer describes the freeze protected conduit 10 being used in a heat transfer application, wherein heat moves between the conduit wall 22 and an aqueous liquid within the fluid passage 24. [Oberholzer, col. 5, lines 2-4] The conduit 12 appears constructed of a uniform material. Further, it is reasonable to assume that the conduit wall 22 material is selected for efficient heat transfer between it and an aqueous liquid in the fluid passage adjacent to it.

c) The structure cited within the Final Office Action is not an enclosure, liquid cannot be contained therein and frozen without assistance of some external structure

Presumably, for the conduit 10 to even contain liquid in the fluid passage 24, it must be connected to some other containing structure, which must also contact the liquid (as illustrated the conduit cannot contain a liquid). Oberholzer does not disclose an infinite conduit; but neither does the patent teach what type of structure the conduit 10 is used within. This ambiguity inherent in Oberholzer prevents any clear teaching regarding freezing dynamics within the freeze protected conduit.

Though Oberholzer teaches enclosed structures, e.g. FIG. 6, there is no clear teaching within those portions of the a centrally disposed insert as cited by the Final Office Action. Neither is there any teaching within the parts of Oberholzer not related to FIGS 1 and 1a of a structure configured to cause fluid to begin to freeze at a location or set of locations. Of course, this assertion is supported by the lack of any citation within the Final Office Action to these other portions of Oberholzer.

d) Even if liquid could be contained and frozen within the conduit of Oberholzer, the patent does not teach a structure that causes fluid to begin to freeze at a location or set of locations

Because there is no teaching within Oberholzer of how liquid is to be contained within the conduit, it is difficult to conceive how freezing would occur within the conduit. If freezing started elsewhere, it might well advance axially from one end of the conduit to the other along the fluid passage 24. In this situation, there is no structure within the conduit to choose in which end of it freezing first occurs–that depends entirely upon the external structure in which the conduit is placed.Accordingly, there is no way in which the conduit is configured to cause a fluid to begin to freeze at one or more locations within it.

If freezing starts within the freeze protected conduit, presumably from exposing its exterior wall to an ambient environment, freezing might well occur *anywhere* along the interior surface of the conduit. Surely, heat will move from the wall 22 and into the ambient; so too will heat move from the liquid into the wall 22. At some point, somewhere within the conduit, liquid will begin to freeze. But Oberholzer teaches no structure that determines a specific location or even a set of locations where freezing would initially occur.

e) Even if the conduit of Oberholzer contained a structure that determines a specific initial location of freezing, the structure taught would not show a conduit configured for freezing to advance toward the compressible insert

As mentioned above, if freezing occurs first within the freeze protected conduit of Oberholzer, that freezing starts somewhere along the inner wall of the conduit. In the device of Oberholzer, once freezing has started, it will progress along the inner surface of the conduit *parallel* to the insert. Thus, instead of starting in an initial location and advancing toward a compressible insert, freezing would start in that location and move laterally relative to the insert.

f) Each of the independent claims 25, 47, and 70 and their respective dependant claims, are all allowable over Oberholzer for at least one of the above reasons.

Claim 25

The independent Claim 25 is directed to an apparatus for preventing cracking of a liquid system. The apparatus comprises an *enclosure*; and one or more compressible objects immersed in the enclosure. Further, the enclosure is configured to *cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards the one or more compressible objects*. As described above in point c), the conduit cited within the Final Office Action is not an enclosure; further, as in point d) Oberholzer does not disclose or even suggest a system with an enclosure configured to cause a fluid to begin to freeze at selected locations; and further still, as in point e) Oberholzer does not disclose or suggest a system with an enclosure configured for freezing to advance towards one or more compressible objects. For at least these three reasons, the independent Claim 25 is allowable over the teachings of Oberholzer.

Claims 26-35 are all dependent on the independent Claim 25. As discussed above, the independent Claim 25 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claims 26-35 are all also allowable as being dependent on an allowable base claim.

Claim 47

The amended independent Claim 47 is directed to a method of preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers. The method comprises the steps of providing an enclosure; immersing one or more compressible

objects in the enclosure; configuring the enclosure to *cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure*; and immersing one or more *compressible objects in the enclosure at the other locations*. As described above in point c), the conduit cited within the Final Office Action is not an enclosure; further, as in point d) Oberholzer does not disclose or even suggest a system with an enclosure configured to cause a fluid to begin to freeze at selected locations; and further still, as in point e) Oberholzer does not disclose or suggest a system with an enclosure configured for freezing to advance towards one or more compressible objects. For at least these three reasons, the independent Claim 47 is allowable over the teachings of Oberholzer.

Claims 48-57 are all dependent on the independent Claim 47. As discussed above, the independent Claim 47 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claims 48-57 are all also allowable as being dependent on an allowable base claim.

Claim 70

The amended independent Claim 70 is directed to an apparatus for preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers. The apparatus comprises an enclosure, wherein the enclosure being capable of contracting and expanding between a minimum volume condition and a maximum volume condition with fluid expansion during freezing, and further wherein the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure. As described above in point c), the conduit cited within the Final Office Action is not an enclosure; further, as in point d) Oberholzer does not disclose or even suggest a system with an enclosure configured to cause a fluid to begin to freeze at selected locations. For at least these two reasons, the independent Claim 70 is allowable over the teachings of Oberholzer.

2. Claims 27 and 49 are nonobvious over Oberholzer alone or in view of Mihara

As mentioned above, Claims 27 and 49 were rejected under § 103(a) as being unpatentable over Oberholzer, either alone or in view of Mihara. 6,186,722 to Shirai. Claim 27 depends from claim 25 and claim 49 depends from claim 47. As stated above, for purposes of this appeal, claim 27 stands or falls with claim 25, and claim 49 stands or falls with claim 47. Accordingly, the teachings of Mihara are irrelevant and are not discussed in this Appeal Brief.

As discussed above, the independent Claim 25 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claim 27 is also allowable as being dependent on an allowable base claim.

As discussed above, the independent Claim 47 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claim 49 is also allowable as being dependent on an allowable base claim.

3. Claims 133 and 134 are allowable over Oberholzer.

Within the Final Office Action, Claims 133, and 134 were rejected under § 102(b) as being anticipated by Oberholzer.

a) The disclosure of Oberholzer is non-enabling for freeze protected conduit that includes an insert without a membrane

The Final Office Action mentions that because Oberholzer discloses a freeze protected conduit 10 including an insert 10 that comprises a membrane 18 and a compressible elastomeric material 14, but says that since the membrane is "preferably" included that Oberholzer discloses such conduit without the membrane.

However, in order to serve as an anticipating reference, the reference must enable that which it is asserted to anticipate. See *Elan Pharm., Inc. v. Mayo Found. For Med. Educ. & Research*, 346 F.3d 1051, 1054 (Fed. Cir. 2003). The specification of Oberholzer makes clear that rather than being an optional feature, the membrane is an essential part of the disclosed invention. Accordingly, Oberholzer provides no teaching to one skilled in the art that experimentation will produce a functional apparatus without inclusion of a membrane.

i) No drawing depicts an insert without a membrane

Nowhere in the disclosure of Oberholzer does a compressible insert appear without a membrane between it and any adjacent fluid passage. Furthermore, nowhere in the specification and drawings, except in use of the word "preferably" is the notion of including a compressible insert without a membrane introduced.

In contrast to the hint provided by the word "preferably," much of the remainder of the specification, drawings, and claims is spent discussing various aspects of the membrane, including the undesirable consequences should the membrane be breached.

ii) Oberholzer teaches that the freeze protected conduit would loose functionality if the membrane were not included

Oberholzer describes that "if membrane 18 is punctured, the compressible elastomeric material 14 will not immediately lose its ability to assist in freeze protection." [Oberholzer, col. 5, lines 45-49] This indicates that a small leak in the membrane will eventually render the insert non-functional. A reasonable inference is that an unlined compressible elastomeric material insert would quickly become non-functional.

b) The structure cited within the Final Office Action is not an enclosure, liquid cannot be contained therein and frozen without assistance of some external structure

Presumably, for the conduit 10 to even contain liquid in the fluid passage 24, it must be connected to some other containing structure, which must also contact the liquid (as illustrated the conduit cannot contain a liquid). Oberholzer does not disclose an infinite conduit; but neither does the patent teach what type of structure the conduit 10 is used within.

Though Oberholzer teaches enclosed structures, e.g. FIG. 6, there is no clear teaching within those portions of the a centrally disposed insert as cited by the Final Office Action. Finally, only the conduit 10 is referenced to have a 'preferable' membrane: the membranes of the enclosed structures are disclosed as necessary.

c) Each of the independent claims 133 and 134 are allowable over Oberholzer for at least one of the above reasons.

Claim 133

The independent claim 133 recites a method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers. The method comprises the steps of: providing an *enclosure*; and immersing one or more compressible objects in the enclosure, wherein the one or more compressible objects are *not* covered by a separate membrane. As described above in point a), the disclosure of Oberholzer is non-enabling for a system with a compressible object not covered by a separate membrane; and as in b), the conduit cited within the Final Office Action is not an enclosure. For at least these two reasons, the independent Claim 133 is allowable over the teachings of Oberholzer.

Claim 134

Independent claim 134 recites an apparatus for preventing cracking of a liquid system. The apparatus comprises at least one heat exchanger; at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages; at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port, wherein the one or more compressible objects are *not* covered by a separate membrane. As described above in point a), the disclosure of Oberholzer is non-enabling for a system with a compressible object not covered by a separate membrane. Furthermore, Oberholzer does not disclose an uncovered membrane enclosed in a

heat exchanger having an inlet and an outlet port. For at least these two reasons, the independent Claim 134 is allowable over the teachings of Oberholzer.

C. CONCLUSION

For the above reasons, it is respectfully submitted that the claims 1-13, 25-35, 47-57, 70, and 133-135 are allowable over the cited prior art references. Therefore, a favorable indication is respectfully requested.

VIII. CLAIMS APPENDIX

Below is a true and accurate listing of the claims involved in this appeal.

1. An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger;
at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages;
at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and
one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port;
wherein, the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects.

2. The apparatus of claim 1, wherein the compressible objects accommodate a predetermined level of fluid expansion.

3. The apparatus of claim 2, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

4. The apparatus of claim 1, wherein the compressible objects being capable of contracting and expanding between a minimum volume and a maximum volume.

5. The apparatus of claim 1, wherein the compressible objects being secured within the inlet port and the outlet port.

6. The apparatus of claim 1, wherein the compressible objects are confined within the inlet port and the outlet port.

7. The apparatus of claim 1, wherein the compressible objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

8. The apparatus of claim 7, wherein the sponge or foam is hydrophobic.

9. The apparatus of claim 1, wherein the compressible object is encapsulated in a gas or liquid impermeable package.

10. The apparatus of claim 9, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

11. The apparatus of claim 9, wherein the package has a hydrophilic surface or coating.

12. The apparatus of claim 9, wherein the package is formed of plastic material.

13. The apparatus of claim 12, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

25. An apparatus for preventing cracking of a liquid system, comprising:
an enclosure; and
one or more compressible objects immersed in the enclosure;
wherein, the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards the one or more compressible objects.

26. The apparatus of claim 25, wherein the objects accommodate a predetermined level of fluid expansion.

27. The apparatus of claim 26, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

28. The apparatus of claim 25, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

29. The apparatus of claim 25, wherein the objects are a hydrophobic foam.

30. The apparatus of claim 25, wherein the object are a hydrophobic sponge.

31. The apparatus of claim 25, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

32. The apparatus of claim 25, wherein the objects are encapsulated in a gas or liquid impermeable package.

33. The apparatus of claim 32, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

34. The apparatus of claim 32, wherein the package is formed of plastic material.

35. The apparatus of claim 34, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

47. A method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, the method comprising the steps of:
providing an enclosure;
configuring the enclosure to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure; and
immersing one or more compressible objects in the enclosure at the other locations.

48. The method of claim 47, wherein the objects accommodate a predetermined level of fluid expansion.

49. The method of claim 48, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

50. The method of claim 47, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

51. The method of claim 47, wherein the objects are a hydrophobic foam.

52. The method of claim 47, wherein the objects are a hydrophobic sponge.

53. The method of claim 47, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

54. The method of claim 47, wherein the objects are encapsulated in a gas or liquid impermeable package.

55. The method of claim 54, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

56. The method of claim 54, wherein the package is formed of plastic material.

57. The method of claim 56, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

70. (Currently Amended) An apparatus for preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, comprising an enclosure, wherein the enclosure being capable of contracting and expanding between a minimum volume condition and a maximum volume condition with fluid expansion during freezing, and further wherein the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure.

133. A method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, the method comprising the steps of:
providing an enclosure; and
immersing one or more compressible objects in the enclosure, wherein the one or more compressible objects are not covered by a separate membrane.

134. An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger;
at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages;
at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and
one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port,

wherein the one or more compressible objects are not covered by a separate membrane.

135. An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger including a plurality of microchannels;
at least one inlet port extending through a first opening for conveying a fluid to the plurality of microchannels;
at least one outlet port extending through a second opening for discharging the fluid from the plurality of microchannels; and
one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port;
wherein, the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port.

IX. EVIDENCE APPENDIX

Pursuant to 37 C.F.R. § 41.37(c)(1)(ix), the following is a statement setting forth where in the record the evidence of this appendix was entered by the examiner:

Evidence Description:	Where Entered:
U.S. Patent Serial No. 6,119,729	In the "Notice of References Cited" included with the Office Action mailed on April 28, 2005
Response filed November 18, 2005	Office Action mailed December 12, 2005
Office Action mailed December 12, 2005	Examiner Office Action
Original Specification	Examiner Office Action mailed May 6, 2004

X. RELATED PROCEEDINGS APPENDIX

There are no related proceedings.

Respectfully submitted,
HAVERSTOCK & OWENS LLP

Dated: 4-28-06

By: Thomas B. Haverstock
Thomas B. Haverstock
Reg. No.: 32,571

Attorneys for Applicants

CERTIFICATE OF MAILING (37 CFR§ 1.8(a))

I hereby certify that this paper (along with any referred to as being attached or enclosed) is being deposited with the U.S. Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to the: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450

HAVERSTOCK & OWENS LLP.

Date: 4-28-06 **By:** [signature]

PATENT
Attorney Docket No.: COOL-00901

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Group Art Unit: 3744
Mark Munch et al.	Examiner: Jiang, Chen Wen
Serial No.: 10/643,641	
Filed: August 18, 2003	**RESPONSE TO OFFICE ACTION MAILED ON September 16, 2005**
For: **REMEDIES TO PREVENT CRACKING IN A LIQUID SYSTEM**	160 North Wolfe Road Sunnyvale, California 94086 (408) 530-9700
	Customer No.: 28960

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed on September 16, 2005, please amend the above-identified application as follows:

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 18 of this paper.

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims regarding the present application. In reading this, text added by the amendment is underlined and canceled text appears in ~~strikethrough~~.

1. (Currently Amended) An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger;
at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages;
at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and
one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port;
wherein, the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects.

2. (Original) The apparatus of claim 1, wherein the compressible objects accommodate a predetermined level of fluid expansion.

3. (Original) The apparatus of claim 2, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

4. (Original) The apparatus of claim 1, wherein the compressible objects being capable of contracting and expanding between a minimum volume and a maximum volume.

5. (Original) The apparatus of claim 1, wherein the compressible objects being secured within the inlet port and the outlet port.

6. (Original) The apparatus of claim 1, wherein the compressible objects are confined within the inlet port and the outlet port.

7. (Original) The apparatus of claim 1, wherein the compressible objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

8. (Original) The apparatus of claim 7, wherein the sponge or foam is hydrophobic.

9. (Original) The apparatus of claim 1, wherein the compressible object is encapsulated in a gas or liquid impermeable package.

10. (Original) The apparatus of claim 9, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

11. (Original) The apparatus of claim 9, wherein the package has a hydrophilic surface or coating.

12. (Original) The apparatus of claim 9, wherein the package is formed of plastic material.

13. (Previously Presented) The apparatus of claim 12, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

14. (Withdrawn) An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger having a top element and a bottom element;
a plurality of channels and passages formed within the bottom element to provide flow of a fluid therethrough; and
one or more compressible objects positioned within one or more of the channels and passages such that in an uncompressed state the compressible objects reduce a volume of each of the channels and passages having compressible objects and further wherein under pressure exerted within the channels and passages the compressible objects are compressed to increase the volume of each of the channels and passages.

15. (Withdrawn) The apparatus of claim 14, wherein the compressible objects accommodate a predetermined level of fluid expansion.

16. (Withdrawn) The apparatus of claim 15, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

17. (Withdrawn) The apparatus of claim 14, wherein the compressible objects being capable of contracting and expanding between a minimum volume and a maximum volume.

18. (Withdrawn) The apparatus of claim 14, wherein the compressible objects being positioned with a portion of the top element.

19. (Withdrawn) The apparatus of claim 14, wherein the compressible objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

20. (Withdrawn) The apparatus of claim 14, wherein the compressible objects are encapsulated in a gas or liquid impermeable package.

21. (Withdrawn) The apparatus of claim 20, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

22. (Withdrawn) The apparatus of claim 20, wherein the package has a hydrophilic surface or coating.

23. (Withdrawn) The apparatus of claim 20, wherein the package is formed of plastic material.

24. (Withdrawn) The apparatus of claim 23, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

25. (Currently Amended) An apparatus for preventing cracking of a liquid system, comprising:
an enclosure; and

one or more compressible objects immersed in the enclosure;
wherein, the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards the one or more compressible objects.

26. (Original) The apparatus of claim 25, wherein the objects accommodate a predetermined level of fluid expansion.

27. (Original) The apparatus of claim 26, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

28. (Original) The apparatus of claim 25, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

29. (Original) The apparatus of claim 25, wherein the objects are a hydrophobic foam.

30. (Original) The apparatus of claim 25, wherein the object are a hydrophobic sponge.

31. (Original) The apparatus of claim 25, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

32. (Original) The apparatus of claim 25, wherein the objects are encapsulated in a gas or liquid impermeable package.

33. (Original) The apparatus of claim 32, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

34. (Original) The apparatus of claim 32, wherein the package is formed of plastic material.

35. (Previously Presented) The apparatus of claim 34, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

36. (Withdrawn) An apparatus for preventing cracking of a liquid system, comprising:

a housing having at least one inlet chamber and at least one outlet chamber; and one or more compressible objects immersed in the inlet and outlet chambers.

37. (Withdrawn) The apparatus of claim 36, wherein the objects accommodate a predetermined level of fluid expansion.

38. (Withdrawn) The apparatus of claim 37, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

39. (Withdrawn) The apparatus of claim 36, wherein the objects having a size and volume proportion to an amount of fluid in the chambers.

40. (Withdrawn) The apparatus of claim 36, wherein the objects are a hydrophobic foam.

41. (Withdrawn) The apparatus of claim 36, wherein the objects are a hydrophobic sponge.

42. (Withdrawn) The apparatus of claim 36, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

43. (Withdrawn) The apparatus of claim 36, wherein the objects are encapsulated in a gas or liquid impermeable package.

44. (Withdrawn) The apparatus of claim 43, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

45. (Withdrawn) The apparatus of claim 43, wherein the package is formed of plastic material.

46. (Withdrawn) The apparatus of claim 45, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

47. (Currently Amended) A method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, the method comprising the steps of:
providing an enclosure; ~~and~~
configuring the enclosure to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure; and
immersing one or more compressible objects in the enclosure at the other locations.

48. (Original) The method of claim 47, wherein the objects accommodate a predetermined level of fluid expansion.

49. (Original) The method of claim 48, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

50. (Original) The method of claim 47, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

51. (Original) The method of claim 47, wherein the objects are a hydrophobic foam.

52. (Original) The method of claim 47, wherein the objects are a hydrophobic sponge.

53. (Original) The method of claim 47, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

54. (Original) The method of claim 47, wherein the objects are encapsulated in a gas or liquid impermeable package.

55. (Original) The method of claim 54, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

56. (Original) The method of claim 54, wherein the package is formed of plastic material.

57. (Previously Presented) The method of claim 56, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, and PVC.

58. (Withdrawn) A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and
immersing one or more compressible objects in the inlet and outlet chambers

59. (Withdrawn) The method of claim 58, wherein the objects accommodate a predetermined level of fluid expansion.

60. (Withdrawn) The method of claim 59, wherein the expansion occurs upon change of phase of an enclosed material from liquid to solid.

61. (Withdrawn) The method of claim 59, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

62. (Withdrawn) The method of claim 58, wherein the objects having a size and volume proportion to an amount of fluid in the chambers.

63. (Withdrawn) The method of claim 58, wherein the objects are a hydrophobic foam.

64. (Withdrawn) The method of claim 58, wherein the objects are a hydrophobic sponge.

65. (Withdrawn) The method of claim 58, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

66. (Withdrawn) The method of claim 58, wherein the objects are encapsulated in a gas or liquid impermeable package.

67. (Withdrawn) The method of claim 66, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

68. (Withdrawn) The method of claim 66, wherein the package is formed of plastic material.

69. (Withdrawn) The method of claim 68, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

70. (Currently Amended) An apparatus for preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, comprising an enclosure, wherein the enclosure being capable of contracting and expanding between a minimum volume condition and a maximum volume condition with fluid expansion during freezing<u>, and further wherein the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure.</u>

71. (Withdrawn) An apparatus for preventing cracking in a pump, comprising:
a housing having at least one inlet chamber and at least one outlet chamber, the inlet and outlet chambers having a relatively narrowed central portion and substantially identical expanded end portions; and
means for initiating freezing from the narrowed central portion to the expanded end portions.

72. (Withdrawn) The apparatus of claim 71, wherein the means for initiating comprises at least one metallic insert mounted at a location in at least one of the inlet and outlet chambers.

73. (Withdrawn) The apparatus of claim 72, wherein the metallic insert is made of one of the following: copper, gold, silver, or a material of high thermal conductivity, such as silicon, aluminum, or a metal.

74. (Withdrawn) The apparatus of claim 72, wherein the metallic insert is coated with nickel or copper.

75. (Withdrawn) A method of preventing cracking in a pump, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber, the inlet and outlet chambers having a relatively narrowed central portion and substantially identical expanded end portions; and
providing means for initiating freezing from the narrowed central portion to the expanded end portions.

76. (Withdrawn) The method of claim 75, wherein the step of providing means for initiating comprises disposing at least one metallic insert at a location in at least one of the inlet and outlet chambers.

77. (Withdrawn) The method of claim 76, wherein the metallic insert is made of one of the following: copper, gold, silver, or a material of high thermal conductivity, such as silicon, aluminum, or a metal.

78. (Withdrawn) The apparatus of claim 76, wherein the metallic insert is coated with nickel or copper.

79. (Withdrawn) An apparatus for preventing cracking in a liquid system, comprising:
an enclosure; and
at least one air pocket disposed in the enclosure, the air pocket positioned farthest away from a location where liquid begins to freeze in the enclosure.

80. (Withdrawn) The apparatus of claim 79, wherein the air pocket having a volume proportion to an amount of fluid in the enclosure.

81. (Withdrawn) The apparatus of claim 79, wherein the air pocket accommodates a predetermined level of fluid expansion .

82. (Withdrawn) The apparatus of claim 81, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

83. (Withdrawn) An apparatus for preventing cracking of a liquid system, comprising:
a housing having at least one inlet chamber and at least one outlet chamber; and
at least one air pocket disposed in the inlet and outlet chambers, the air pocket positioned farthest away from a location where liquid begins to freeze in the chambers.

84. (Withdrawn) The apparatus of claim 83, wherein the air pocket having a volume proportional to an amount of fluid in the chambers.

85. (Withdrawn) The apparatus of claim 84, wherein the proportional is between 5% and 25%.

86. (Withdrawn) The apparatus of claim 83, wherein the air pocket accommodates a predetermined level of fluid expansion .

87. (Withdrawn) The apparatus of claim 86, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

88. (Withdrawn) A method of preventing cracking of a liquid system, the method comprising the steps of:
providing an enclosure; and
disposing at least one air pocket in the enclosure, the air pocket positioned farthest away from a location where liquid begins to freeze in the enclosure.

89. (Withdrawn) The method of claim 88, wherein the air pocket having a volume proportion to an amount of fluid in the enclosure.

90. (Withdrawn) The method of claim 88, wherein the air pocket accommodates a predetermined level of fluid expansion.

91. (Withdrawn) The method of claim 90, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

92. (Withdrawn) A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and
disposing at least one air pocket in the inlet and outlet chambers, the air pocket positioned farthest away from a location where liquid begins to freeze in the chambers.

93. (Withdrawn) The method of claim 92, wherein the air pocket having a volume proportion to an amount of fluid in the chambers.

94. (Withdrawn) The method of claim 92, wherein the air pocket accommodates a predetermined level of fluid expansion.

95. (Withdrawn) The method of claim 94, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

96. (Withdrawn) An apparatus for preventing cracking of a liquid system, comprising:
an enclosure for holding liquid having a plurality of walls; and
at least one flexible object coupled to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible object increases a volume of the enclosure.

97. (Withdrawn) The apparatus of claim 96, wherein the flexible object accommodates a predetermined level of fluid expansion.

98. (Withdrawn) The apparatus of claim 97, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

99. (Withdrawn) The apparatus of claim 96, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

100. (Withdrawn) The apparatus of claim 96, wherein the flexible object being secured within the enclosure.

101. (Withdrawn) The apparatus of claim 96, wherein the flexible object is made of one of the following: rubber, plastic or foam.

102. (Withdrawn) The apparatus of claim 96, wherein the enclosure is a tubing.

103. (Withdrawn) An apparatus for preventing cracking of a liquid system, comprising:
a housing for holding liquid having at least one inlet chamber and at least one outlet chamber structure; and
at least one flexible object coupled to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible object increases a volume of the housing.

104. (Withdrawn) The apparatus of claim 103, wherein the flexible object accommodates a predetermined level of fluid expansion.

105. (Withdrawn) The apparatus of claim 104, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

106. (Withdrawn) The apparatus of claim 103, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

107. (Withdrawn) The apparatus of claim 103, wherein the flexible object being secured within the inlet and outlet chambers.

108. (Withdrawn) The apparatus of claim 103, wherein the flexible object is made of one of the following: rubber, plastic or foam.

109. (Withdrawn) A method of preventing cracking of a liquid system, the method comprising the steps of:
providing an enclosure for holding liquid having a plurality of walls; and
disposing at least one flexible object to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible object increases a volume of the enclosure, the flexible object accommodating a predetermined level of fluid expansion.

110. (Withdrawn) The method of claim 109, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

111. (Withdrawn) The method of claim 109, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

112. (Withdrawn) The method of claim 109, wherein the flexible object is made of one of the following: rubber, plastic or foam.

113. (Withdrawn) The method of claim 109, wherein the enclosure is a tubing.

114. (Withdrawn) A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing for holding liquid having at least one inlet chamber and at least one outlet chamber; and
disposing at least one flexible object to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible object increases a volume of the housing, the flexible objects accommodating a predetermined level of fluid expansion.

115. (Withdrawn) The method of claim 114, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

116. (Withdrawn) The method of claim 114, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

117. (Withdrawn) The method of claim 114, wherein the flexible object is made of one of the following: rubber, plastic or foam.

118. (Withdrawn) An apparatus for preventing cracking in a pump, comprising:
a housing having at least one inlet chamber and at least one outlet chamber; and
a plurality of spaced apart flexible objects coupled to form a portion of at least one wall of the housing such that pressure exerted on the plurality of spaced apart flexible objects increases a volume of the housing.

119. (Withdrawn) The apparatus of claim 118, wherein the flexible objects accommodate a predetermined level of fluid expansion.

120. (Withdrawn) The apparatus of claim 119, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

121. (Withdrawn) The apparatus of claim 118, wherein the flexible objects being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

122. (Withdrawn) The apparatus of claim 118, wherein the pump is electro-osmotic.

123. (Withdrawn) The apparatus of claim 118, wherein the flexible objects are made of elastomer hinges.

124. (Withdrawn) The apparatus of claim 118, wherein the flexible objects are made of one of the following: plastic, rubber, or foam.

125. (Withdrawn) The apparatus of claim 118, wherein the flexible objects are fastened to rigid plates of the housing.

126. (Withdrawn) A method of preventing cracking in a pump, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and
disposing a plurality of spaced apart flexible objects to form at least one wall of the housing such that pressure exerted on the plurality of spaced apart flexible objects increase a volume of the housing, the plurality of spaced apart flexible objects accommodating a predetermined level of fluid expansion.

127. (Withdrawn) The method of claim 126, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

128. (Withdrawn) The method of claim 126, wherein the flexible objects being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

129. (Withdrawn) The method of claim 126, wherein the pump is electro-osmotic.

130. (Withdrawn) The method of claim 126, wherein the flexible objects are made of elastomer hinges.

131. (Withdrawn) The method of claim 126, wherein the flexible objects are made of one of the following: plastic, rubber or foam.

132. (Withdrawn) The method of claim 126, wherein the flexible objects are fastened to rigid plates of the housing.

New Claims

133. (New) A method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, the method comprising the steps of:

providing an enclosure; and

immersing one or more compressible objects in the enclosure, wherein the one or more compressible objects are not covered by a separate membrane.

134. (New) An apparatus for preventing cracking of a liquid system, comprising:

at least one heat exchanger;

at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages;

at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and

one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port, wherein the one or more compressible objects are not covered by a separate membrane.

135. (New) An apparatus for preventing cracking of a liquid system, comprising:

at least one heat exchanger including a plurality of microchannels;

at least one inlet port extending through a first opening for conveying a fluid to the plurality of microchannels;

at least one outlet port extending through a second opening for discharging the fluid from the plurality of microchannels; and

one or more compressible objects each coupled to at least one of the inlet port and outlet port in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port;

wherein, the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port.

REMARKS

Applicant respectfully requests further examination and reconsideration in view of the arguments set forth fully below. Claims 1-132 were previously pending. Of the above claims, claims 14-24, 36-46, 58-69 and 71-132 were previously withdrawn from consideration. In the Office Action mailed September 16, 2005, claims 1-13, 25-35, 47-57 and 70 have been rejected or alternately withdrawn from consideration. Because the prior-filed amendment was not properly considered or entered, the above amendment is identical to the amendment submitted in the Response filed August 29, 2005. The Applicants respectfully, but strongly, traverse this action for the reasons set forth fully below.

Response to Restriction/Election

Within the Office Action, claims 1-13, 25-35, 47-57 and 70 as amended in the response filed August 29, 2005 ("the newly amended claims") were withdrawn by the Examiner as being directed to an invention independent or distinct from the invention originally claimed. The reasoning for the refusal to enter is flawed. The contention that "the amended claims do not read on Applicant's election of Species X (Fig. 10) [because] the amended limitations have not been disclosed in Fig. 10," does not demonstrate why the newly amended claims are directed to a different invention than were the original claims, and in fact cannot so demonstrate. In fact the claims include each and every element of the previous claims and only additional elements are added. As such, ***the claims necessarily cover the identical invention previously claimed, but with further elements.*** **Accordingly, the applicants renew their request for consideration of the previously filed amendment and respectfully request that the finality of the rejection be withdrawn.**

No support is provided for the proposition that adding limitations to the claims somehow eliminates other limitations in the claims. Indeed, there is no reasonable support for such a proposition. The elected invention included, among other things compressible objects provided for reducing a volume until compressed. Those compressible objects are still in the claims after the amendment; indeed no element, nor even a single word (other than the word "and" which was merely moved within a claim) is cancelled from the amended claims.

The Office Action also includes a contention that, since the Applicants have received an action of on the merits for the originally presented invention, this invention has been

constructively elected by original presentation for prosecution on the merits. The doctrine of original presentation appears to relate only to claims and thus has no bearing in this matter, since an explicit election has already been made. See MPEP §821.03 (Referring to the invention "originally claimed.") In this case, because the claims 1-13, and 25-35 are generic over at least one species other than species X, their original presentation would not constitute an election of only the subject matter of species X.

The election of species X, compressible objects disposed in fluid segments of a cooling loop, does not exclude limitations discussed as associated with systems such as the one of FIG. 10 elsewhere in the specification. Note that in lines 10-12 of page 15, the specification discusses the inclusion of various techniques for freeze prevention discussed elsewhere within the system of FIG. 10. The fact that FIG. 10 does not explicitly illustrate the added limitations is not a valid argument against their inclusion in a claim to an invention within the species represented by FIG. 10. If it were, prosecution following an election of species would essentially be moot, as an Applicant would be unable to rely on the full breadth of disclosure relating to the elected species to support narrowing amendments to claims. The Applicant's right to limit claims by amendment is well settled. See In re Wertheim, 541 F.2d 257, 263 Should the Examiner disagree, he is invited to point out where case or statutory law proscribes an Applicant's right to narrow a claim to a species based on anything other than the original figure representing that species.

For at least these reasons, the Applicants traverse the propriety of the holding that claims 1-13, 25-35, 47-57 and 70 as amended in the Response of August 29, 2005 do not read on Applicant's elected species X. Should the Examiner disagree, the Applicants point out that the Board of Patent Appeals and Interferences has noted that this decision is appealable and directed that the Examiner should "reject the claims...on the ground that they are not directed to the elected subject matter" (instead of reasserting a withdrawal). See Ex Parte Jan-Ivar Arvidsson Appeal No. 95-3114, 1997 WL 1883768 (Footnote 4, discussing MPEP §821.)

Unconsidered Claims

The Office Action was unresponsive to new claims 133 and 134 presented within the Applicants previous response. The withdrawal of claims as drawn to a non-elected invention was not applied to these new claims. The Applicants believe these claims are in condition for allowance over Oberholzer (described below) because Oberholzer fails to teach, disclose, or even suggest a system in which compressible objects are directly exposed to a liquid without an

intervening membrane. The Applicants hope that these claims will be properly addressed within the next Office Action.

Rejections Under 35 U.S.C. § 102

The remarks below are identical to those made within the previous response, and relate to the identical amendments included above.

Within the Office Action, Claims 1, 2, 4-13, 25, 26, 28-35, 47, 48, 50-57 and 70 have been rejected under 35 U.S.C. 102(b) as anticipated by U.S. Patent Number 6,119,729 to Oberholzer et al. (hereinafter "Oberholzer"). Applicant respectfully traverses this rejection.

The cited portion of Oberholzer describes a freeze protection apparatus for a solar thermal collector. A freeze-protected conduit 14 includes a compressible insert 20 which comprises a compressible elastomeric material that is fully sealed on all its sides and ends by a liquid impermeable membrane 18. Furthermore, Oberholzer discloses using freeze-protected conduits throughout the solar thermal collector:

> Every fluid passage in solar thermal collector 50 may be adapted for use with the freeze protection apparatus of the present invention. Referring to FIGS. 6 and 7, a section of a typical fluid passage 80 is shown adapted for use with the freeze protection apparatus of the present invention by defining such fluid passage 80 with flexible conduit 82 wherein flexible conduit 82 is disposed within rigid structural support member 84. Also disposed within rigid structural support member 84 is compressible elastomeric material 88. [Column 8, Lines 10-19]

The system disclosed in the cited portion of Oberholzer has compressible elements in every portion of the system that can be exposed to cold temperature conditions. These portions are first to freeze during exposure to cold temperature conditions.

> Fluid passages between the collector unit 50 and supply line 64 (FIG. 6), including supply manifold 66, and within supply line 64, may be exposed to cold temperature conditions to some extent. The same is true with respect to fluid passages between collector unit 50 and return line 76, including return manifold 74, and within return line 76. In this respect, where such fluid passages are exposed to cold temperature conditions, the corresponding conduit is protected from freeze carnage by the present invention. [Column 8, Lines 46-53]

Thus, the system does not place compressible objects at locations which freeze later. Further, the compressible objects used in Oberholzer include a compressible element and a separate membrane element.

The present invention relates to systems and methods to prevent cracking in a liquid system. These include methods and systems where compressible objects are disposed in enclosures within a liquid system and where the systems are configured to select locations where

the liquid begins to freeze in the enclosure, and to arrange for freezing to start from the locations and advance towards the compressible objects. Unlike the present invention, the cited portion of Oberholzer does not disclose or even suggest a system with an apparatus configured to cause a fluid to begin to freeze at selected locations, and for freezing to advance towards one or more compressible objects. In addition, the present invention discloses embodiments in which the compressible objects do not include a separate membrane element, a feature which the cited portion of Oberholzer does not describe. The new claims recite limitations related to this feature.

The amended independent Claim 1 is directed to an apparatus for preventing cracking of a liquid system. The apparatus includes at least one heat exchanger; at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages; at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port; wherein, the heat exchanger is configured so that the fluid in the inlet port and the outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects. As described above, the cited portion of Oberholzer does not disclose or even suggest a system with an apparatus configured to cause a fluid to begin to freeze at selected locations, and for freezing to advance towards one or more compressible objects. For at least these reasons, the independent Claim 1 is allowable over the teachings of Oberholzer.

Claims 2-13 are all dependent on the independent Claim 1. As discussed above, the independent Claim 1 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claims 2-13 are all also allowable as being dependent on an allowable base claim.

The amended independent Claim 25 is directed to an apparatus for preventing cracking of a liquid system. The apparatus comprises an enclosure; and one or more compressible objects immersed in the enclosure. Further, the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards the one or more compressible objects. As described above, the cited portion of Oberholzer does not disclose or even suggest a system with an apparatus configured to cause a fluid to begin to freeze at selected locations, and for freezing to advance towards one or more compressible objects. For at least these reasons, the independent Claim 25 is allowable over the teachings of Oberholzer.

Claims 26-35 are all dependent on the independent Claim 25. As discussed above, the independent Claim 25 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claims 26-35 are all also allowable as being dependent on an allowable base claim.

The amended independent Claim 47 is directed to a method of preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers. The method comprises the steps of providing an enclosure; immersing one or more compressible objects in the enclosure; configuring the enclosure to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure; and immersing one or more compressible objects in the enclosure at the other locations. As described above, the cited portion of Oberholzer does not disclose or even suggest a system with an apparatus configured to cause a fluid to begin to freeze at selected locations, and for freezing to advance towards one or more compressible objects. For at least these reasons, the independent Claim 47 is allowable over the teachings of Oberholzer.

Claims 48-57 are all dependent on the independent Claim 47. As discussed above, the independent Claim 47 is allowable over the teachings of Oberholzer. Accordingly, the dependent Claims 48-57 are all also allowable as being dependent on an allowable base claim.

The amended independent Claim 70 is directed to an apparatus for preventing cracking of a liquid system. The system includes one or more pumps and one or more heat exchangers. The apparatus comprises an enclosure, wherein the enclosure being capable of contracting and expanding between a minimum volume condition and a maximum volume condition with fluid expansion during freezing, and further wherein the enclosure is configured to cause a fluid to begin to freeze at one or more locations in the enclosure, and for freezing to advance towards other locations in the enclosure. As described above, the cited portion of Oberholzer does not disclose or even suggest a system with an apparatus configured to cause a fluid to begin to freeze at selected locations, or for freezing to advance towards one or more compressible objects. For at least these reasons, the independent Claim 70 is allowable over the teachings of Oberholzer.

Rejections Under 35 U.S.C. § 103

The remarks below are identical to those made within the previous response, and relate to the identical amendments included above.

Within the Office Action, Claims 3, 27 and 49 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Oberholzer.

Claim 3 is dependent on the independent Claim 1. As discussed above, the independent Claim 1 is allowable. Accordingly, the dependent Claims 3 is also allowable as being dependent on an allowable base claim.

Claim 27 is dependent on the independent Claim 25. As discussed above, the independent Claim 25 is allowable. Accordingly, the dependent Claims 27 is also allowable as being dependent on an allowable base claim.

Claim 49 is dependent on the independent Claim 47. As discussed above, the independent Claim 47 is allowable. Accordingly, the dependent Claim 49 is also allowable as being dependent on an allowable base claim.

For the reasons given above, Applicant respectfully submits that the Claims 1-13, 25-35, 47-57, 70, 133, and 134 are now in a condition for allowance, and allowance at an early date would be appreciated. Should the Examiner have any questions or comments, the Examiner is encouraged to call the undersigned at (408) 530-9700 to discuss the same so that any outstanding issues can be expeditiously resolved.

Respectfully submitted,
HAVERSTOCK & OWENS LLP

Dated: 11-16-05

By: Thomas B. Haverstock

Thomas B. Haverstock
Reg. No.: 32,571
Attorneys for Applicant

CERTIFICATE OF MAILING (37 CFR§ 1.8(a))

I hereby certify that this paper (along with any referred to as being attached or enclosed) is being deposited with the U.S. Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to the: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450

HAVERSTOCK & OWENS LLP.

Date: 11-16-05 By:

Jcl

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/643,641	08/18/2003	Mark Munch	COOL-00901	4440

7590 12/12/2005

Thomas B. Haverstock
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Sunnyvale, CA 94086

DEC 15 2005

EXAMINER	
JIANG, CHEN WEN	
ART UNIT	PAPER NUMBER
3744	

DATE MAILED: 12/12/2005

DOCKETED

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	Application No.	Applicant(s)	
	10/643,641	MUNCH ET AL.	
	Examiner	Art Unit	
	Chen-Wen Jiang	3744	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *18 November 2005*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-135* is/are pending in the application.

4a) Of the above claim(s) *14-24,36-46,58-69 and 71-132* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-13,25-35,47-57,70 and 133-135* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *18 August 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *101305*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Response to Amendment

1. Applicant's request for reconsideration of the finality of the rejection of the last Office action is persuasive and, therefore, the finality of that action is withdrawn.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 1-13 and 135 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. "[T]he fluid in the inlet and outlet port freezes later than the fluid elsewhere in the heat exchanger, and for freezing to advance towards the one or more compressible objects" and "the heat exchanger is configured so that fluid within the plurality of microchannels freezes before fluid within the outlet port and the inlet port" have not been disclosed in the specification.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 25,26,28-35,47,48,50-57,70,133 and 134 are rejected under 35 U.S.C. 102(b) as being anticipated by Oberholzer et al. (U.S. Patent Number 6,119,729).

Oberholzer et al. disclose a freeze protection apparatus. Referring to Figs.1 and 1a, a freeze-protected conduit 10 comprises an elongated conduit 12 for conveying or containing liquid, and an elongated, compressible elastomeric material 14 disposed within the conduit 12. Examples of compressible elastomeric material 14 include foam, rubber, foamed neoprene and silicone sponge rubber. Preferably, the compressible elastomeric material 14 is fully sealed on all its sides and ends by a liquid impermeable membrane 18 to form an insert 20 which is disposed inside of conduit 12. It is noted that Oberholzer et al. disclose "preferably" to have membrane means the membrane is optional in the system. A choice for membrane material is a thin metal foil coated with a protective layer such as a plastic film. Another preferred choice is a thin, flexible, plastic membrane materials include polyester and fluoropolymers. Referring to Figs.6 and 7, heat exchanger 50 has supply header 68 (inlet chamber), discharge header 72 (outlet chamber) and collectors 56. Every fluid system in solar collector 50 may be adapted for use with the freeze protection apparatus of the apparatus. Referring to Fig.1, preferably insert 20 is disposed along the axis of conduit, particularly where conduit 12 is used in heat transfer application. Therefore, the fluid begins to freeze on the conduit and advance toward the insert 20. Under the principals of inherency, if a prior art device, in its normal and usual operation, would necessarily perform the method claimed, then the method claimed will be considered to be anticipated by the prior art device. When the prior art device is the same as a device described in

the specification for carrying out the claimed method, it can be assumed the device will inherently perform the claimed process.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 27 and 49 are rejected under 35 U.S.C. 103(a) as being unpatentable over Oberholzer et al. (U.S. Patent Number 6,119,729).

The reference discloses the compression calculation claimed except for the 5 to 25 percent of the amount of fluid expansion. It is not patentable, however, to discover the optimum of workable ranges of the expansion by routine experimentation. *In re Aller,* 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955), MPEP Section 2144.05(IIA).

8. Claims 27 and 49 are rejected under 35 U.S.C. 103(a) as being unpatentable over Oberholzer et al. (U.S. Patent Number 6,119,729) in view of Mihara (JP 10099592 with machine English translation).

The reference discloses the compression calculation claimed except for the 5 to 25 percent of the amount of fluid expansion. Mihara disclose a method and apparatus to prevent a pump from being damaged due to the freezing of water by incorporating a freely compressible body in a chamber of the pump. The freely compressible hollow part 32 is incorporated into the pump chamber 1 absorbs the expansion in volume of ice to eliminate the pressure on the inner

wall of the pump. The hollow part 32 is formed by foam which can be contracted freely. The ratio of the hollow part 32 volume to the pump chamber volume is made about 10% or more. Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to provide the apparatus of Oberholzer et al. with an expansion in view of Mihara so as to absorption of fluid expansion between 5-25%.

Conclusion

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Chen-Wen Jiang whose telephone number is (571) 272-4809. The examiner can normally be reached on Monday-Thursday from 8:00 to 6:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Melba Bumgarner can be reached on (571) 272-4709. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Chen-Wen Jiang
Primary Examiner

FORM PTO-1449 (Modified)

U.S. Department of Commerce Patent and Trademark Office

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Use Several Sheets If Necessary)

(37 CFR § 1.98(b))

Attorney Docket No.: COOL-00901	Serial No.: 10/643,641
Applicants: Mark Munch et al.	
Filing Date: August 18, 2003	Group Art Unit: 3744

U.S. PATENT DOCUMENTS

Examiner Initials		Serial / Patent Number	Issue Date	Applicant / Patentee	Class	Subclass	Filing Date
	AA						
	AB						
	AC						
	AD						
	AE						
	AF						
	AG						
	AH						
	AI						
	AJ						

FOREIGN PATENTS OR PUBLISHED FOREIGN PATENT APPLICATIONS

		Document Number	Publication Date	Country / Patent Office	Class	Subclass	Translation Yes	Translation No
CJ	AK	JP 1-256775	10/13/89	JP	F 25 D	9/00		X
	AL							
	AM							
	AN							
	AO							

OTHER DOCUMENTS (Including Author, Title, Date, Relevant Pages, Place of Publication)

	AP	
	AQ	
	AR	
	AS	
	AT	
	AU	
	AV	
	AW	
	AX	
	AY	
	AZ	

Examiner: CJ | Date Considered: 12/7/05

EXAMINER: Initial citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

PATENT
Atty. Docket No. COOL-00901

REMEDIES TO PREVENT CRACKING IN A LIQUID SYSTEM

Related Application

This application claims priority under 35 U.S.C. § 119(e) of the co-pending U.S. provisional patent application Serial Number 60/444,269, filed on January 31, 2003, and titled "REMEDIES FOR FREEZING IN CLOSED-LOOP LIQUID COOLING FOR ELECTRONIC DEVICES." The provisional patent application Serial Number 60/444,269, filed on January 31, 2003, and titled "REMEDIES FOR FREEZING IN CLOSED-LOOP LIQUID COOLING FOR ELECTRONIC DEVICES" is hereby incorporated by reference.

Field of the Invention

The present invention relates to an apparatus and method of preventing cracking of a liquid system, such as may be useful for transferring heat from electronic devices and components thereof. In particular, the invention utilizes a variety of means and objects to protect against expansion of water-based solutions when frozen.

Background of the Invention

When water or many other fluid mixtures are cooled below freezing, the material changes from a liquid state to a solid state, and undergoes a significant expansion in volume, which is as much as 10% or more for water or water-based mixtures. When water freezes in a pipe, it undergoes a similar expansion. Water that has frozen in pipes or other confined spaces does more than simply clog the pipes and block flow. When freezing occurs in a confined space like a steel pipe, the ice will expand and exert extreme pressure which is often enough to crack the pipe and cause serious damage. This phenomenon is a common failure mode in hot-water heating systems and automotive cooling systems.

Ice forming in a pipe does not always cause cracking where ice blockage occurs. Rather, following a complete ice blockage in a pipe, continued freezing and expansion inside the pipe can cause water pressure to increase downstream. The increase in water pressure leads to pipe failure and/or cracking. Upstream from the ice

blockage the water can retreat back towards its inlet source, and there is little pressure buildup to cause cracking.

Liquid cooling systems for electronic devices are occasionally subjected to sub-freezing environments during shipping, storage, or in use. Since these systems are going to be frozen on occasion, they must be designed to tolerate the expansion of water when frozen. Additives, such as antifreeze, are potentially poisonous and flammable and can damage mechanical components, sensitive sensors, and electronics, which is why pure or substantially pure water is typically the coolant of choice.

What is needed is an apparatus for and method of preventing cracking in a liquid cooling system that can tolerate a predetermined level of freezing and expansion inside confined spaces without damaging electronic components or affecting system performance.

Summary of the Invention

A liquid system utilizing size and volume reducing means, air pockets, compressible objects, and flexible objects is provided to protect against expansion of water-based solutions when frozen. In such a system, pipes, pumps, and heat exchangers are designed to prevent cracking of their enclosures and chambers.

In a first aspect of the invention, an apparatus for preventing cracking of a liquid system is disclosed. The apparatus comprises at least one heat exchanger; one or more inlet ports extending through a first opening for conveying a fluid to a plurality of channels and passages; one or more outlet ports extending through a second opening for discharging the fluid from the plurality of channels and passages; and one or more compressible objects positioned substantially adjacent the inlet ports and the outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet ports and the outlet ports and further wherein pressure exerted on the compressible objects increases a volume of the inlet ports and the outlet ports.

The compressible objects can preferably accommodate a predetermined level of fluid expansion. The predetermined level of fluid expansion can be between 5 to 25 percent. The compressible objects are preferably capable of contracting and expanding between a minimum volume and a maximum volume. The compressible objects can

be secured within the inlet port and the outlet port. Alternatively, the compressible objects can be positioned at any location throughout the system. The compressible objects can be made of sponge, foam, air-filled bubbles, balloons and encapsulated in a hermetically sealed package. The package can be made of metallic material, metallized plastic sheet material, or plastic material. The plastic materials can be selected from teflon, mylar, nylon, PET, PVC, PEN or any other suitable package.

In a second aspect of the invention, an apparatus for preventing cracking of a liquid system is disclosed. The apparatus comprises at least one heat exchanger having a top element and a bottom element; a plurality of channels and passages formed within the bottom element to provide flow of a fluid therethrough; and one or more compressible objects positioned within one or more of the plurality of channels and passages such that in an uncompressed state the compressible objects reduce a volume of each of the plurality of channels and passages having one or more of the compressible objects and further wherein under pressure exerted within the channels and passages the compressible objects are compressed to increase the volume of each of the plurality of channels and passages.

In a further separate aspect of the invention, an apparatus for preventing cracking of a liquid system is provided. The system preferably includes one or more pumps and one or more heat exchangers. The apparatus comprises an enclosure, wherein a size and volume occupied by fluid within the enclosure is minimized. The pump can be an electro-osmotic pump.

The enclosure is preferably capable of contracting and expanding between a minimum size and volume condition and a maximum size and volume condition.

In a second separate aspect of the invention, an apparatus for preventing cracking of a liquid system is disclosed. The apparatus comprises a housing having at least one inlet chamber and at least one outlet chamber, wherein a size and volume occupied by fluid within the inlet and outlet chambers is minimized.

The inlet and outlet chambers are preferably capable of contracting and expanding between a minimum size and volume condition and a maximum size and volume condition. The inlet and outlet chambers can be separated by a pumping structure or mechanism.

In a further separate aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The system includes at least one pump and at least one heat exchanger. The method comprises the steps of providing an enclosure and minimizing a size and volume occupied by fluid within the enclosure.

______In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing a housing having at least one inlet chamber and at least one outlet chamber; and minimizing a size and volume occupied by fluid within the inlet and outlet chambers.

In a further aspect of invention, an apparatus for preventing cracking of a liquid system is provided. The system includes at least one pump and at least one heat exchanger. The apparatus comprises an enclosure and one or more compressible objects immersed in the enclosure.

The objects preferably accommodate a predetermined level of fluid expansion. The predetermined level of fluid expansion is preferably between 5 to 25 percent. The objects preferably have a size and volume proportion to an amount of fluid in the enclosure. The objects can be a hydrophobic foam. Alternatively, the objects can be hydrophobic sponges. Also, the objects can be balloons in hydrophobic bags. The objects can be made of rubber, plastic, foam, sealed foam or rubber, or vacuum laminated foam or rubber. The objects may be enclosed in vacuum laminated bags.

In a further aspect of the invention, an apparatus for preventing cracking of a liquid system is provided. The apparatus comprises a housing having at least one inlet chamber and at least one outlet chamber and one or more compressible objects immersed in the inlet and outlet chambers. The objects preferably have a size and volume proportional to an amount of fluid in the chambers.

In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing an enclosure and immersing one or more compressible objects in the enclosure.

In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing a housing having at least one inlet chamber and at least one outlet chamber and immersing one or more compressible objects in the inlet and outlet chambers.

In a further aspect of the invention, an apparatus for preventing cracking of a liquid system is disclosed. The apparatus comprises an enclosure and one or more air pockets disposed in the enclosure. The air pockets are preferably positioned farthest away from a location where liquid begins to freeze in the enclosure.

The air pockets preferably have a volume proportional to an amount of fluid in the enclosure. The air pockets preferably accommodate a predetermined level of fluid expansion. The predetermined level of fluid expansion is preferably between 5 to 25 percent.

In a further aspect of the invention, an apparatus for preventing cracking of a liquid system is disclosed. The apparatus comprises a housing having at least one inlet chamber and at least one outlet chamber and an one or more air pockets disposed in the inlet and outlet chambers. The air pockets are preferably positioned farthest away from a location where liquid begins to freeze in the chambers. The air pockets preferably have a volume proportion to an amount of fluid in the chambers.

In a further aspect of the invention, a method of preventing cracking of a liquid system is provided. The method comprises the steps of providing an enclosure and disposing one or more air pockets in the enclosure. The air pockets are positioned farthest away from a location where liquid begins to freeze in the enclosure.

In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing a housing having at least one inlet chamber and at least one outlet chamber and disposing one or more air pockets in the inlet and outlet chambers. The air pockets are positioned farthest away from a location where liquid begins to freeze in the chambers.

In a further aspect of the invention, an apparatus for preventing cracking of a liquid system is provided. The apparatus comprises an enclosure for holding liquid having a plurality of walls and at least one flexible object coupled to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible objects increases a volume of the enclosure.

The flexible objects preferably accommodate a predetermined level of fluid expansion. The flexible objects can be spaced apart a predetermined distance. The flexible objects are preferably capable of contracting and expanding between a minimum volume condition and a maximum volume condition. The flexible objects

are preferably secured within the enclosure and deformable under pressure. The flexible objects can be made of rubber. Alternatively, the flexible objects can be made of plastic or foam.

In a further aspect of the invention, an apparatus for preventing cracking of a liquid system is provided. The apparatus comprises a housing having at least one inlet chamber and at least one outlet chamber and at least one flexible object coupled to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible objects increases a volume of the housing. The flexible objects preferably accommodate a predetermined level of fluid expansion.

In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing an enclosure and disposing at least one flexible object to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible objects increases a volume of the enclosure. The flexible objects preferably accommodate a predetermined level of fluid expansion.

In a further aspect of the invention, a method of preventing cracking of a liquid system is disclosed. The method comprises the steps of providing a housing having at least one inlet chamber and at least one outlet chamber and disposing at least one flexible object to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible objects increases a volume of the housing. The flexible objects preferably accommodate a predetermined level of fluid expansion.

Brief Description of the Drawings

Figure 1 illustrates a schematic diagram of a conventional closed-loop cooling system, which includes an electro-osmotic pump and a heat exchanger.

Figure 2 illustrates a schematic diagram of a housing having an inlet chamber and an outlet chamber.

Figure 3 illustrates a schematic diagram of a housing having inlet and outlet chambers reduced in size and volume in accordance with the present invention.

Figure 4 illustrates a schematic diagram of an air pocket disposed in an inlet chamber and an outlet chamber of a housing in accordance with the present invention.

Figure 5 illustrates a schematic diagram of a compressible object disposed in an inlet chamber and an outlet chamber of a housing in accordance with the present invention.

Figure 6A illustrates a schematic diagram of a housing having inlet and outlet chambers and a plurality of spaced apart flexible objects coupled to the chambers.

Figure 6B illustrates a schematic diagram of a housing having inlet and outlet chambers and a plurality of spaced flexible objects coupled to the chambers, the flexible objects being displaced during fluid expansion to prevent cracking.

Figure 7A illustrates a schematic diagram of compressible objects coupled to inlet and outlet ports within a heat exchanger.

Figure 7B illustrates a schematic diagram of compressible objects disposed along a bottom surface of a heat exchanger within adjacent microchannels.

Figure 8A illustrates a schematic diagram of compressible objects coupled to walls of fluid filled tubing within a heat rejector.

Figure 8B illustrates a schematic diagram of compressible objects disposed along a length of fluid filled tubing within a heat rejector.

Figure 9 illustrates a schematic diagram of compressible objects disposed within fluid filled channels of a plate within a heat rejector.

Figure 10 illustrates a schematic diagram of compressible objects disposed in fluid segments of a cooling loop.

Figure 11 illustrates a schematic diagram of a housing having an inlet chamber and an outlet chamber and a plurality of spaced apart flexible objects coupled to the chambers.

Figure 12 illustrates a schematic diagram of a housing having inlet and outlet chambers and a plurality of spaced apart flexible objects coupled to the chambers, the flexible objects being displaced during fluid expansion to prevent cracking.

Figure 13 illustrates a flow chart illustrating steps of a preferred method of one embodiment of the present invention.

Figure 14 illustrates a schematic diagram of a housing having inlet and outlet chambers having a relatively narrowed central portion and substantially identical expanded end portions.

Detailed Description of the Preferred Embodiment

Reference will now be made in detail to the preferred and alternative embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it should be noted that the present invention may be practiced without these specific details. In other instances, well known methods, procedures and components have not been described in detail as not to unnecessarily obscure aspects of the present invention.

Figure 1 shows a schematic diagram of a closed-loop cooling system 100, which includes heat exchanger 20 attached to a heat producing device 55 (shown as an integrated circuit attached to a circuit board, but which could also be a circuit board or other heat producing device), a pump 30 for circulating fluid, a heat rejector 40, which may include a plurality of fins 46 for further assisting in conducting heat away from the system 100, and a controller 50 for a pump input voltage based on a temperature measured at the heat exchanger 20. Fluid flows from an inlet 32, is pulled through a porous structure (not shown) within the pump 30 by electroosmotic forces, and exits through the outlet 34. While the preferred embodiment uses an electroosmotic pump, it will be understood that the present invention can be implemented in a system using other types of pumps.

Still referring to Figure 1, the fluid travels through the heat exchanger 20 and the heat rejector 40 through tubing lengths 114 and 110 before being recycled back to the inlet 32 of the pump 30 via another tubing 112. The controller 50 is understood to be an electronic circuit that takes input signals from thermometers in the heat exchanger 20, or from thermometers in the device 55 being cooled, which signals are transmitted along signal lines 120. The controller 50, based upon the input signals regulates flow through the pump 30 by applying signals to a power supply (not shown) associated with the pump 30 along signal lines 122 to achieve the desired thermal performance.

As fluid temperature drops below freezing, ice forms into a blockage. Continued growth of ice in areas of the system 100 can lead to excessive fluid pressure. The resulting pressure can rupture or damage individual elements, such as the lengths 110, 112, 114 of tubing, channels in the heat exchangers 20 and 40, and/or chambers inside the pump 30. As will be explained and understood in further detail below, the individual elements must be designed in a way that tolerates expansion of the fluid or water when frozen.

In one embodiment, shown in Figure 2, an apparatus or pump 60 includes a housing 68 having an inlet chamber 62 and an outlet chamber 64. A pumping mechanism or structure 69 separates the inlet and outlet chambers 62 and 64 from a bottom surface of the housing 68 to an upper surface of the housing 68. The pumping structure 69 channels liquid from a pump inlet 61 to a pump outlet 66. The chambers 62 and 64 are filled with fluid. Preferably, the liquid used in the pump 60 is water. It is contemplated that any other suitable liquid is contemplated in accordance with the present invention.

Still referring to Figure 2, the pump 60 can be designed so that there are no large pockets of water in any of the chambers 62 and 64. Since water expands as it freezes, ice takes up more room than liquid. When freezing occurs in confined spaces, such as chambers 62 and 64, displacement caused by the expansion of fluids is proportional to an amount of fluid volume in the chambers 62 and 64. Minimizing the size and volume occupied by the chambers 62 and 64 reduces the displacement, and thereby prevents bending, stretching, or cracking of the chambers 62 and 64.

As shown in Figure 3, the volume of inlet and outlet chambers 72 and 74 is substantially reduced compared to the chambers 62 and 64 in Figure 2. As such, the amount of water present in the pump 70 is greatly reduced. Detailed mechanical analysis of the chambers 72 and 74 is required, but the chambers 72 and 74 can be designed to withstand force exerted by frozen water. The inlet and outlet chambers 72 and 74 can be capable of contracting and expanding between a minimum size and volume condition and a maximum size and volume condition. It should be understood that the tubing lengths 110, 112, and 114 in Figure 1 can be reduced in size and volume to reduce displacement caused by fluid expansion in areas of the system 100 (Figure 1).

In another embodiment, as shown in Figure 4, an apparatus or pump 80 includes a housing 88 having an inlet chamber 82 and an outlet chamber 84. A pumping structure 89 separates the inlet and outlet chambers 82 and 84 from a bottom surface of the housing 88 to an upper surface of the housing 88. The pumping structure 89 channels liquid from a pump inlet 81 to a pump outlet 86. The chambers 82 and 84 are filled with fluid to a large extent. Preferably, the liquid used in the pump 80 is water. It is contemplated that any other suitable liquid is contemplated in accordance with the present invention.

Still referring to Figure 4, air pockets 85 and 87 are disposed in the inlet and outlet chambers 82 and 84. The air pockets 85 and 87 are preferably positioned farthest away from a location where fluid begins to freeze in the chambers 82 and 84. Expansion of the ice upon freezing in the chambers 82 and 84 will take up some space occuppied by the air pockets 85 and 87, and a cause a slight increase of pressure in the chambers 82 and 84. However, air is compressible enough that it can be significantly compressed with relatively small forces, such that the expansion of the ice is easily accommodated. Preferably, the air pockets 85 and 87 have a volume proportion to an amount of fluid in the chambers 82 and 84. The air pockets 85 and 87 can preferably accommodate a predetermined level of fluid expansion between five to twenty five percent.

As mentioned before, ice forming in a confined space does not typically cause a break where initial ice blockage occurs. Rather, following a complete ice blockage in a confined space, continued freezing and expansion inside the confined space cause

fluid pressure to increase downstream. The fluid pressure will reach a maximum at a last location to freeze in a hermetically sealed system. The pressure can be very large, unless there is a trapped air pocket in that region. Thermal design of the chambers 82 and 84 can be altered to select a location where the fluid begins to freeze, and to arrange for freezing to start from one location and advance continuously towards an air pocket at another location. For example, if there is an air pocket at the top surface of a chamber, the fluid should be nucleated at the bottom surface of the chamber. As the fluid begins to freeze at the bottom surface of the chamber, ice expansion displaces water and compresses the air pocket. Since air is easily compressible, the chamber can freeze completely without generating large forces at any location in the chamber.

To arrange a location of initial freezing in the chamber, it may be necessary to provide a thermal path from the location of initial freezing to its surroundings. As the fluid or chamber is cooled from above a freezing point, the thermal path serves to efficiently reject heat stored in the location. For example, an optional metallic insert 288 is mounted from the location of initial freezing in the chamber to the top surface of the chamber would serve. Preferably, the metallic insert 288 is formed of a material that will not contaminate the fluid such as copper. Alternatively, reducing the size and volume of the chamber or reducing package insulation in the chamber could also work. A critical factor is use of any material or structure that assists a particular location become cold fastest, and so that progression of freezing is continuous from that location to the air pockets 85 and 87 of Figure 4.

In some cases, it may be difficult to control the positioning and location of the air pockets 85 and 87 in the chambers 82 and 84. Further, it may be difficult to dispose an air pocket in each chamber of the system 100 (Figure 1). In a further embodiment, as shown in Figure 5, one or more compressible objectss 95 and 97 are immersed in pump 90. The pump 90 includes a housing 98 having an inlet chamber 92 and an outlet chamber 94. A pumping structure 99 separates the inlet and outlet chambers 92 and 94 from a bottom surface of the housing 98 to an upper surface of the housing 98. The pumping structure 99 channels liquid from a pump inlet 91 to a pump outlet 96. The chambers 92 and 94 are filled with fluid to a large extent. Preferably, the liquid used in the pump 90 is water. It is contemplated that any other suitable liquid is contemplated in accordance with the present invention.

Still referring to Figure 5, the one or more compressible objectss 95 and 97 are immersed and coupled to inlet and outlet chambers 92 and 94. The objects 95 and 97 can be a hydrophobic foam or sponge. Preferably, the objects 95 and 97 accommodate a predetermined level of fluid expansion between five to twenty five percent. To accommodate the fluid expansion, the objects 95 and 97 can preferably have a size and volume proportional to an amount of fluid in the chambers 92 and 94.

The objects 95 and 97 can be comprised of a compressible material, such as an open-cell or closed-cell foam, rubber, sponge, air-filled bubbles, elastomer, or any related material, and a protective layer covering all surfaces of the compressible material. A purpose of having the protective layer is to prevent contact between the compressible material and a surrounding fluid. The protective layer can be formed by many means, including wrapping and sealing, dip-coating, spray-coating, or other similar means. The protective layer can be a vacuum laminated cover, such as a spray-on layer, a deposited layer, or a layer formed by reacting or heating surfaces of the compressible material. In addition, it is possible to form a protective layer on the surface of the compressible material by thermally fusing, melting, or chemically modifying the surface. The protective layer can be flexible enough so that a volume of the compressible material can be reduced by pressure. In order to achieve this degree of flexibility, the protective layer can be much thinner than the compressible material. Further, the protective layer can be formed from a material that is not chemically attacked by the fluid used in the cooling system, or degraded by temperature cycles above and below freezing. The protective layer can be hermetically sealed so that gas cannot enter or leave the volume within the protective layer. The protective layer can be formed from a variety of materials, including teflon, mylar, polyethylene, nylon, PET, PVC, PEN or any other suitable plastic, and can additionally include metal films on interior or exterior surfaces to improve hermeticity. In addition, the protective layer can be a metallized plastic sheet material, as used in potato chip packaging, and can serve as an impervious layer, blocking all gas and liquid diffusion. Furthermore, in cases where occasional bubbles are moving through the cooling system, as when an electroosmotic pump is generating hydrogen and oxygen gas bubbles, the protective layer can be hydrophilic to help reduce the possibility that the bubbles will attach to the surfaces.

In a further embodiment, as shown in Figure 6A, an apparatus or pump 103 includes a housing 108 having an inlet chamber 102 and an outlet chamber 104. A pumping structure 109 separates the inlet and outlet chambers 102 and 104 from a bottom surface of the housing 108 to an upper surface of the housing 108. The pumping structure 109 channels liquid from a pump inlet 101 to a pump outlet 106. The chambers 102 and 104 are filled with fluid to a large extent. Preferably, the liquid used in the pump 103 is water. It is contemplated that any other suitable liquid is contemplated in accordance with the present invention.

Still referring to Figure 6A, a plurality of spaced apart flexible objects 105 and 107 are coupled to the inlet and outlet chambers 102 and 104. In this embodiment, the flexible objects 105 and 107 are preferably constructed from a flexible material, such as rubber or plastic. The flexible material is preferably designed and arranged such that it can be partially displaced to accommodate expansion of ice without cracking itself or other rigid elements of the inlet and outlet chambers 102 and 104. Preferably, the flexible objects 105 and 107 accommodate a predetermined level of fluid expansion between five to twenty five percent. The flexible objects can be spaced apart from one another a predetermined distance. Preferably, the flexible objects 105 and 107 are capable of contracting and expanding between a minimum volume condition and a maximum volume condition. Alternatively, the flexible objects 105 and 107 are secured within the chambers 102 and 104.

Figure 7A illustrates a schematic diagram of compressible objects 132 and 134 coupled to inlet and outlet ports 131 and 135 within a heat exchanger 130. Fluid generally flows from one or more inlet ports 131 and flows along a bottom surface 137 in microchannels 138 of any configuration and exits through the outlet port 135, as shown by arrows. The compressible objects 132 and 134 are preferably designed and arranged such that it can be partially displaced to accommodate expansion of ice without cracking itself or other rigid elements of the inlet and outlet ports 131 and 135 in Figure 7A.

Figure 7B illustrates a schematic diagram of compressible objects 145 disposed along a bottom surface 147 of a heat exchanger 140 within microchannels 148. As shown in Figure 7B, the compressible objects 145 can be arranged within the microchannels 148 such that the compressible objects 145 form part of a seal from a

top surface 149 to the bottom surface 147. In both Figures 7A and 7B, compressible objects act as freeze protection within a heat exchanger. The positioning of the compressible objects 145 is intended to minimize flow resistance, and to avoid degrading heat transfer from the bottom surface 147 to the fluid. Placement of the compressible objects 145 on sides of the microchannels is also possible, although less advantageous than the positioning as shown in Figure 8A. Positioning on the bottom surface 148 would severely degrade performance of the heat exchanger 140 because of a high thermal resistance of the compressible objects 145.

Figure 8A illustrates a schematic diagram of compressible objects 152 and 154 coupled to walls 151 and 155 of fluid filled tubing 150 within a heat rejector. The tubing 150 can be substantially longer than other portions of the system, for example centimeters in length in certain parts of the system 100 (Figure 1), and as much as a meters in length in other parts. Placement of a length of the compressible objects 152 and 154 to the walls 151 and 155 of the tubing 150 will act as freeze protection within a heat rejector. Alternatively, as shown in Figure 8B, compressible element 165, such as compressible foam structures, can be threaded along a length of the tubing 160. The compressible element 165 can float freely within the tubing 160. Because the compressible element 165 is thinner than the tubing 160, it can simply be threaded without concern for forming a blockage in the tubing 160. A length of the compressible elements 165 will vary according to the lengths of the tubing 160.

Figure 9 illustrates a schematic diagram of various possible configurations for compressible objects 171, 173, 175 and 177 disposed within fluid filled channels 170 of a plate 180 within a heat rejector. As shown in Figure 9, fluid can be routed through the channels 170 disposed within the plate 180 that allows fluid flow between a fluid inlet 172 and a fluid outlet 174. A heat rejector can include fins 190 mounted to and in thermal contact with the plate 180. The compressible objects 171, 173, 175 and 177 disposed within the channels 170 provide freeze protection, thereby improving performance of the entire system.

In addition to the use of size and volume reducing means, air pockets, compressible objects, and compressible objects discussed above, other techniques can be used to prevent cracking in a liquid cooling system, as would be recognized by one of ordinary skill in the art. For example, as shown in Figure 10, compressible elements

can partly fill all fluid segments of a cooling loop. In all these cases, it will be appreciated by one of ordinary skill that routine mechanical design analysis is useful to compute stress throughout the cooling system including but not limited to the chambers, lengths of tubing, and other enclosures that contain either the air pockets and compressible objects to design a system for which that stresses do not accumulate in any location in sizes large enough to cause the enclosures to fail. In a closed-loop cooling system for an electronic device, relatively large reservoirs of fluid are likely to be in the chambers of the pump or the tubing in a heat exchanger. System design should strive to eliminate these volumes of fluid, thereby reducing the reservoirs at their source. Failing that, or if large volumes of fluid are needed to guarantee sufficient fluid over extended use, the embodiments described above can reduce forces generated during freezing to manageable levels.

In another embodiment, shown in Figure 11, an apparatus or pump 200 includes a housing 208 having an inlet chamber 202 and an outlet chamber 204. A pumping structure 209 separates the inlet and outlet chambers 202 and 204 from a bottom surface of the housing 208 to an upper surface of the housing 208. The pumping structure 209 channels liquid from a pump inlet 201 to a pump outlet 206. The chambers 202 and 204 are filled with fluid. Preferably, the liquid used in the pump 200 is water. It is contemplated that any other suitable liquid is contemplated in accordance with the present invention.

Still referring to Figure 11, the housing 208 can be designed to withstand expansion of the fluid when freezing occurs. A plurality of flexible objects 210 are coupled to at least one wall of the housing 208. The housing 208 consists of rigid plates and support the chambers 202 and 204. The plates make up a plurality of sides of the chambers 202 and 204 and are joined by the flexible objects 210. The flexible objects 210 can be fastened to the plates. The flexible objects 210 can be formed on any or each of the plurality of sides of the chambers 202 and 204, which includes corner edges, and allow the plates to be displaced outward when acted upon by force, as shown in Figure 12. The flexible objects can be elastomer hinges or any suitable polymer hinge, so long as it can alter its shape when met by force.

In an alternative embodiment, as shown in Figure 13, a method of preventing cracking in a pump is disclosed beginning in the Step 300. In the Step 310, a housing

is provided having an inlet chamber and an outlet chamber separated by a pumping structure. In the Step 320, a plurality of spaced apart flexible objects are disposed form at least one wall of the housing such that pressure exerted on the plurality of spaced apart flexible objects increases a volume of the housing. The flexible objects can accommodate a predetermined level of fluid expansion.

The predetermined level of fluid can be between five to twenty five percent. The flexible objects are preferably spaced apart a predetermined distance. Additionally, the flexible objects are preferably capable of contracting and expanding between a minimum volume condition and a maximum volume condition. The pump can be electro-osmotic. The housing can include rigid plates. Furthermore, the flexible objects can be fastened to the rigid plates. The flexible objects can be made of rubber, plastic or foam.

In another embodiment, shown in Figure 14, an apparatus or pump 400 includes a housing 410 having hourglass-shaped inlet and outlet chambers. The hourglass-shaped chambers can have a relatively narrowed middle or central portion 405 and substantially identical expanded end portions 407. A pumping structure 420 separates the inlet and outlet chambers from a bottom surface of the housing 410 to an upper surface of the housing 410. The apparatus can include a thermal path from a location of initial freezing to its surroundings.

As the fluid or chamber is cooled from above a freezing point, the thermal path serves to efficiently reject heat stored in the location. For example, an optional metallic insert 430 is mounted from the location of initial freezing in the chamber to the top surface of the chamber would serve. Preferably, the metallic insert 430 is formed of a material that will not contaminate the fluid such as copper. A critical factor is use of any material or structure that assists a particular location become cold fastest, and so that progression of freezing is continuous from that location to the expanded end portions 407 of the chambers. The combination of having a hourglass-shaped chambers and the metallic insert 430 allows for freezing to initiate at the narrowed middle or central portion 405 of the hourglass-shaped chambers and expand outward to the expanded end portions 407.

In the above-described embodiments, the present invention is applied to a pump or a housing having an inlet chamber and an outlet chamber. Alternatively, the

present invention may be applied to any enclosure in a liquid cooling system. The liquid cooling system preferably includes an electro-osmotic pump and a heat exchanger. As such, the size and volume reducing means, the air pockets, the compressible objects, and the compressible objects can be applied to any or each enclosure in the system, including tubing, of the liquid cooling system.

The present invention has been described in terms of specific embodiments incorporating details to facilitate the understanding of the principles of construction and operation of the invention. Such reference herein to specific embodiments and details thereof is not intended to limit the scope of the claims appended hereto. It will be apparent to those skilled in the art that modification s may be made in the embodiment chosen for illustration without departing from the spirit and scope of the invention.

Claims

What is claimed is:

1. An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger;
at least one inlet port extending through a first opening for conveying a fluid to a plurality of channels and passages;
at least one outlet port extending through a second opening for discharging the fluid from the plurality of channels and passages; and
one or more compressible objects coupled to the inlet and outlet ports in an unpressured condition such that the compressible objects reduce a volume of the inlet port and the outlet port and further wherein pressure exerted on the compressible object increases a volume of the inlet port and the outlet port.

2. The apparatus of claim 1, wherein the compressible objects accommodate a predetermined level of fluid expansion.

3. The apparatus of claim 2, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

4. The apparatus of claim 1, wherein the compressible objects being capable of contracting and expanding between a minimum volume and a maximum volume.

5. The apparatus of claim 1, wherein the compressible objects being secured within the inlet port and the outlet port.

6. The apparatus of claim 1, wherein the compressible objects are confined within the inlet port and the outlet port.

7. The apparatus of claim 1, wherein the compressible objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

8. The apparatus of claim 7, wherein the sponge or foam is hydrophobic.

9. The apparatus of claim 1, wherein the compressible object is encapsulated in a gas or liquid impermeable package.

10. The apparatus of claim 9, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

11. The apparatus of claim 9, wherein the package has a hydrophilic surface or coating.

12. The apparatus of claim 9, wherein the package is formed of plastic material.

13. The apparatus of claim 12, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

14. An apparatus for preventing cracking of a liquid system, comprising:
at least one heat exchanger having a top element and a bottom element;
a plurality of channels and passages formed within the bottom element to provide flow of a fluid therethrough; and
one or more compressible objects positioned within one or more of the channels and passages such that in an uncompressed state the compressible objects reduce a volume of each of the channels and passages having compressible objects and further wherein under pressure exerted within the channels and passages the compressible objects are compressed to increase the volume of each of the channels and passages.

15. The apparatus of claim 14, wherein the compressible objects accommodate a predetermined level of fluid expansion.

16. The apparatus of claim 15, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

17. The apparatus of claim 14, wherein the compressible objects being capable of contracting and expanding between a minimum volume and a maximum volume.

18. The apparatus of claim 14, wherein the compressible objects being positioned with a portion of the top element.

19. The apparatus of claim 14, wherein the compressible objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

20. The apparatus of claim 14, wherein the compressible objects are encapsulated in a gas or liquid impermeable package.

21. The apparatus of claim 20, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

22. The apparatus of claim 20, wherein the package has a hydrophilic surface or coating.

23. The apparatus of claim 20, wherein the package is formed of plastic material.

24. The apparatus of claim 23, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

25. An apparatus for preventing cracking of a liquid system, comprising:
an enclosure; and
one or more compressible objects immersed in the enclosure.

26. The apparatus of claim 25, wherein the objects accommodate a predetermined level of fluid expansion.

27. The apparatus of claim 26, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

28. The apparatus of claim 25, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

29. The apparatus of claim 25, wherein the objects are a hydrophobic foam.

30. The apparatus of claim 25, wherein the object are a hydrophobic sponge.

31. The apparatus of claim 25, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

32. The apparatus of claim 25, wherein the objects are encapsulated in a gas or liquid impermeable package.

33. The apparatus of claim 32, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

34. The apparatus of claim 32, wherein the package is formed of plastic material.

35. The apparatus of claim 34, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

36. An apparatus for preventing cracking of a liquid system, comprising: a housing having at least one inlet chamber and at least one outlet chamber; and one or more compressible objects immersed in the inlet and outlet chambers.

37. The apparatus of claim 36, wherein the objects accommodate a predetermined level of fluid expansion.

38. The apparatus of claim 37, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

39. The apparatus of claim 36, wherein the objects having a size and volume proportion to an amount of fluid in the chambers.

40. The apparatus of claim 36, wherein the objects are a hydrophobic foam.

41. The apparatus of claim 36, wherein the objects are a hydrophobic sponge.

42. The apparatus of claim 36, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

43. The apparatus of claim 36, wherein the objects are encapsulated in a gas or liquid impermeable package.

44. The apparatus of claim 43, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

45. The apparatus of claim 43, wherein the package is formed of plastic material.

46. The apparatus of claim 45, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

47. A method of preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, the method comprising the steps of:
providing an enclosure; and
immersing one or more compressible objects in the enclosure.

48. The method of claim 47, wherein the objects accommodate a predetermined level of fluid expansion.

49. The method of claim 48, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

50. The method of claim 47, wherein the objects having a size and volume proportion to an amount of fluid in the enclosure.

51. The method of claim 47, wherein the objects are a hydrophobic foam.

52. The method of claim 47, wherein the objects are a hydrophobic sponge.

53. The method of claim 47, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

54. The method of claim 47, wherein the objects are encapsulated in a gas or liquid impermeable package.

55. The method of claim 54, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

56. The method of claim 54, wherein the package is formed of plastic material.

57. The method of claim 56, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

58. A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and

immersing one or more compressible objects in the inlet and outlet chambers

59. The method of claim 58, wherein the objects accommodate a predetermined level of fluid expansion.

60. The method of claim 59, wherein the expansion occurs upon change of phase of an enclosed material from liquid to solid.

61. The method of claim 59, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

62. The method of claim 58, wherein the objects having a size and volume proportion to an amount of fluid in the chambers.

63. The method of claim 58, wherein the objects are a hydrophobic foam.

64. The method of claim 58, wherein the objects are a hydrophobic sponge.

65. The method of claim 58, wherein the objects are made of one of the following: sponge, foam, air-filled bubbles, or balloons.

66. The method of claim 58, wherein the objects are encapsulated in a gas or liquid impermeable package.

67. The method of claim 66, wherein the package is formed of metallic barrier material or metallized plastic sheet material.

68. The method of claim 66, wherein the package is formed of plastic material.

69. The method of claim 68, wherein the plastic material is selected from the group teflon, mylar, PET, PEN, PVC, or other suitable plastic materials.

70. An apparatus for preventing cracking of a liquid system, the system including one or more pumps and one or more heat exchangers, comprising an enclosure, wherein the enclosure being capable of contracting and expanding between a minimum size and volume condition and a maximum size and volume condition.

71. An apparatus for preventing cracking in a pump, comprising:
a housing having at least one inlet chamber and at least one outlet chamber, the inlet and outlet chambers having a relatively narrowed central portion and substantially identical expanded end portions; and
means for initiating freezing from the narrowed central portion to the expanded end portions.

72. The apparatus of claim 71, wherein the means for initiating comprises at least one metallic insert mounted at a location in at least one of the inlet and outlet chambers.

73. The apparatus of claim 72, wherein the metallic insert is made of one of the following: copper, gold, silver, or a material of high thermal conductivity, such as silicon, aluminum, or a metal.

74. The apparatus of claim 72, wherein the metallic insert is coated with nickel or copper.

75. A method of preventing cracking in a pump, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber, the inlet and outlet chambers having a relatively narrowed central portion and substantially identical expanded end portions; and
providing means for initiating freezing from the narrowed central portion to the expanded end portions.

76. The method of claim 75, wherein the step of providing means for initiating comprises disposing at least one metallic insert at a location in at least one of the inlet and outlet chambers.

77. The method of claim 76, wherein the metallic insert is made of one of the following: copper, gold, silver, or a material of high thermal conductivity, such as silicon, aluminum, or a metal.

78. The apparatus of claim 76, wherein the metallic insert is coated with nickel or copper.

79. An apparatus for preventing cracking in a liquid system, comprising:
an enclosure; and
at least one air pocket disposed in the enclosure, the air pocket positioned farthest away from a location where liquid begins to freeze in the enclosure.

80. The apparatus of claim 79, wherein the air pocket having a volume proportion to an amount of fluid in the enclosure.

81. The apparatus of claim 79, wherein the air pocket accommodates a predetermined level of fluid expansion .

82. The apparatus of claim 81, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

83. An apparatus for preventing cracking of a liquid system, comprising:
a housing having at least one inlet chamber and at least one outlet chamber; and
at least one air pocket disposed in the inlet and outlet chambers, the air pocket positioned farthest away from a location where liquid begins to freeze in the chambers.

84. The apparatus of claim 83, wherein the air pocket having a volume proportional to an amount of fluid in the chambers.

85. The apparatus of claim 84, wherein the proportional is between 5% and 25%.

86. The apparatus of claim 83, wherein the air pocket accommodates a predetermined level of fluid expansion .

87. The apparatus of claim 86, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

88. A method of preventing cracking of a liquid system, the method comprising the steps of:
providing an enclosure; and
disposing at least one air pocket in the enclosure, the air pocket positioned farthest away from a location where liquid begins to freeze in the enclosure.

89. The method of claim 88, wherein the air pocket having a volume proportion to an amount of fluid in the enclosure.

90. The method of claim 88, wherein the air pocket accommodates a predetermined level of fluid expansion.

91. The method of claim 90, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

92. A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and
disposing at least one air pocket in the inlet and outlet chambers, the air pocket

positioned farthest away from a location where liquid begins to freeze in the chambers.

93. The method of claim 92, wherein the air pocket having a volume proportion to an amount of fluid in the chambers.

94. The method of claim 92, wherein the air pocket accommodates a predetermined level of fluid expansion.

95. The method of claim 94, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

96. An apparatus for preventing cracking of a liquid system, comprising:
an enclosure for holding liquid having a plurality of walls; and
at least one flexible object coupled to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible object increases a volume of the enclosure.

97. The apparatus of claim 96, wherein the flexible object accommodates a predetermined level of fluid expansion.

98. The apparatus of claim 97, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

99. The apparatus of claim 96, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

100. The apparatus of claim 96, wherein the flexible object being secured within the enclosure.

101. The apparatus of claim 96, wherein the flexible object is made of one of the following: rubber, plastic or foam.

102. The apparatus of claim 96, wherein the enclosure is a tubing.

103. An apparatus for preventing cracking of a liquid system, comprising:
a housing for holding liquid having at least one inlet chamber and at least one outlet chamber structure; and
at least one flexible object coupled to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible object increases a volume of the housing.

104. The apparatus of claim 103, wherein the flexible object accommodates a predetermined level of fluid expansion.

105. The apparatus of claim 104, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

106. The apparatus of claim 103, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

107. The apparatus of claim 103, wherein the flexible object being secured within the inlet and outlet chambers.

108. The apparatus of claim 103, wherein the flexible object is made of one of the following: rubber, plastic or foam.

109. A method of preventing cracking of a liquid system, the method comprising the steps of:
providing an enclosure for holding liquid having a plurality of walls; and

disposing at least one flexible object to form a portion of at least one wall of the enclosure such that pressure exerted on the flexible object increases a volume of the enclosure, the flexible object accommodating a predetermined level of fluid expansion.

110. The method of claim 109, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

111. The method of claim 109, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

112. The method of claim 109, wherein the flexible object is made of one of the following: rubber, plastic or foam.

113. The method of claim 109, wherein the enclosure is a tubing.

114. A method of preventing cracking of a liquid system, the method comprising the steps of:
providing a housing for holding liquid having at least one inlet chamber and at least one outlet chamber; and
disposing at least one flexible object to form a portion of at least one of the inlet and outlet chambers such that pressure exerted on the flexible object increases a volume of the housing, the flexible objects accommodating a predetermined level of fluid expansion.

115. The method of claim 114, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

116. The method of claim 114, wherein the flexible object being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

117. The method of claim 114, wherein the flexible object is made of one of the following: rubber, plastic or foam.

118. An apparatus for preventing cracking in a pump, comprising:
a housing having at least one inlet chamber and at least one outlet chamber; and
a plurality of spaced apart flexible objects coupled to form a portion of at least one wall of the housing such that pressure exerted on the plurality of spaced apart flexible objects increases a volume of the housing.

119. The apparatus of claim 118, wherein the flexible objects accommodate a predetermined level of fluid expansion.

120. The apparatus of claim 119, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

121. The apparatus of claim 118, wherein the flexible objects being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

122. The apparatus of claim 118, wherein the pump is electro-osmotic.

123. The apparatus of claim 118, wherein the flexible objects are made of elastomer hinges.

124. The apparatus of claim 118, wherein the flexible objects are made of one of the following: plastic, rubber, or foam.

125. The apparatus of claim 118, wherein the flexible objects are fastened to rigid plates of the housing.

126. A method of preventing cracking in a pump, the method comprising the steps of:
providing a housing having at least one inlet chamber and at least one outlet chamber; and
disposing a plurality of spaced apart flexible objects to form at least one wall of the housing such that pressure exerted on the plurality of spaced apart flexible objects increase a volume of the housing, the plurality of spaced apart flexible objects accommodating a predetermined level of fluid expansion.

127. The method of claim 126, wherein the predetermined level of fluid expansion is between 5 to 25 percent.

128. The method of claim 126, wherein the flexible objects being capable of contracting and expanding between a minimum volume condition and a maximum volume condition.

129. The method of claim 126, wherein the pump is electro-osmotic.

130. The method of claim 126, wherein the flexible objects are made of elastomer hinges.

131. The method of claim 126, wherein the flexible objects are made of one of the following: plastic, rubber or foam.

132. The method of claim 126, wherein the flexible objects are fastened to rigid plates of the housing.

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Abstract

A liquid cooling system utilizing minimal size and volume enclosures, air pockets, compressible objects, and flexible objects is provided to protect against expansion of water-based solutions when frozen. In such a system, pipes, pumps, and heat exchangers are designed to prevent cracking of their enclosures and chambers. Also described are methods of preventing cracking in a liquid cooling system. In all these cases, the system must be designed to tolerate expansion when water is frozen.